ARTICLE V.—The Library shall be divided into TWO CLASSES; the first comprising such work as, from their rarity of value, should not be lent out, all unbound periodicals, and such text books as ought to be found in a library of reference except when required by Committees of the Institute, or by members or holders of second class stock, who have obtained the sanction of the Committee. The second class shall include those books intended for circulation.

ARTICLE VI.—The Secretary shall have authority to loan to members and to holders of second class stock, any work belonging to the SECOND CLASS, subject to the following regulations.

Section 1.—No individual shall be permitted to have more than *two books* out at one time, without a written permission, signed by at least two members of the Library Committee, nor shall a book be kept out more than TWO WEEKS; but if no one has applied for it, the former borrower may renew the loan. Should any person have applied for it the latter shall have the preference.

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Section 3.—Should any book be returned injured, the borrower shall pay for the injury, or replace the book, as the Library Committee may direct; and if one or more books, belonging to a set or sets, be lost, the borrower shall replace them or make full restitution.

ARTICLE VII.—Any person removing from the hall, without permission from the proper authorities, any book, newspaper or other property in charge of the Library Committee, shall be reported to the Committee, who may inflict any fine not exceeding twenty-five dollars.

ARTICLE VIII.—No member or holder of second class stock, whose annual contribution for the current year shall be unpaid or who is in arrears for fines, shall be entitled to the privileges of the Library or Reading Room.

ARTICLE IX.—If any member or holder of second class stock, shall refuse or neglect to comply with the foregoing rules, it shall be the duty of the Secretary to report him to the Committee on the Library.

ARTICLE X.—Any member or holder of second class stock, detected in mutilating the newspapers, pamphlets or books belonging to the Institute shall be deprived of his right of membership, and the name of the offender shall be made public.

MODERN
MOULDING AND PATTERN-MAKING.

A Practical Treatise upon Pattern-Shop and Foundry Work.

EMBRACING THE

MOULDING OF PULLEYS, SPUR GEARS, WORM GEARS, BALANCE-WHEELS, STATIONARY-ENGINE AND LOCOMOTIVE CYLINDERS, GLOBE VALVES, TOOL WORK, MINING MACHINERY, SCREW-PROPELLERS, PATTERN-SHOP MACHINERY, AND THE LATEST IMPROVEMENTS IN ENGLISH AND AMERICAN CUPOLAS.

TOGETHER WITH A LARGE COLLECTION OF

ORIGINAL AND CAREFULLY SELECTED RULES AND TABLES, FOR EVERY-DAY USE IN THE DRAWING-OFFICE, PATTERN-SHOP, AND FOUNDRY.

WITH 165 ILLUSTRATIONS.

BY

JOSEPH P. MULLIN, M.E.

NEW YORK:
D. VAN NOSTRAND, PUBLISHER,
23 MURRAY STREET AND 27 WARREN STREET.
1885.

ELECTROTYPED BY
RAND, AVERY, AND COMPANY,
BOSTON.

PREFACE.

In the pages of this book I have given the result of many years of careful study, and actual personal experience, in the different branches, with the belief that it would be useful to my fellow-workmen. The success which has uniformly attended the several operations detailed at length renders them valuable to manufacturers of similar parts; and those who may wish to follow the plans laid down, in their own practice, can rest assured that they are not merely theoretical, or copied from other works with slight alterations of the text. I have followed every piece in detail, from the drawing-room to the finished casting ready for the machinist. Knowing the great expense of such work, I have not dared to give mere speculations, which might or might not be practically possible. I have simply narrated the work of my hands; and may say, without egotism, that those who have never undertaken work similar to that here described will find my methods expeditious and economical.

It should be understood that I do not put this work forward as a complete guide to pattern-making in all its branches, but refer to this trade only as it is immediately connected with the part directly under discussion.

JOSEPH P. MULLIN.

Arlington, N.J., December, 1884.

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MODERN
MOULDING AND PATTERN-MAKING.

CHAPTER I.

DRAUGHTSMEN, PATTERN-MAKERS, AND MOULDERS.

As this book is intended for the use of draughtsmen, pattern-makers, and moulders, combined, it may be well to consider them individually, and see how and why they are allied to each other. The first in order is

THE DRAUGHTSMAN.

Now, what is a draughtsman? One who draws writings, or designs. To do this, he must understand mathematics, especially geometry and arithmetic. He must be a practical man, and able to design a machine that can be easily constructed, and simple, durable and symmetrical when finished. In fact, it may be said, that to no class of men is the engineering and mechanical world more indebted for progress, than to draughtsmen. And yet how small is usually the credit allowed them! There are, however, "draughtsmen and draughtsmen." There are those for whom the name "draughtsman" is almost too comprehensive. Happily, this is only a very small proportion of the whole, and the majority are men for whom the name is too limited; who are, in

fact, mechanical engineers in every sense of the word. To fulfil their duties satisfactorily, they must be such. They must know every operation which every part of a machine will have to undergo during its manufacture, and all the conditions under which it will work when in the finished machine; and it is here that experience becomes requisite, and mere theoretical education fails altogether. It must also be remembered, that art, as well as science, enters largely into the designing of machinery; and, to borrow a sentence from a well-known author (Ellis A. Davidson), "The true beauty of form in engineering designs follows the same rules as those which render a picture, or a group of statuary, pleasing to the eye; and the graceful forms of a well-designed machine impress the mind with a sense of beauty, of fitness and of power." The design should follow construction, and the machine be built up in the mind, so to speak, before being made in the workshop. These requirements demand an amount of close observation of the practical department of engineering, together with a thorough training in theoretical investigations, which, generally speaking, make them men of more than average ability.

As we have said, draughtsmen, as a rule, get small credit for their share in an engineering achievement; and yet it is, in the main, their ideas and their instructions that have been carried out throughout the work and its execution. The manager, or perhaps the foreman, is looked upon as the man on whom to bestow praise, while the plodding draughtsman, who designed the work perhaps months or years before its completion, is entirely forgotten, although the talent displayed in his department may be much more worthy of eulogium

than any special tact shown in the execution of the work. It must be understood, that we do not wish to underrate the value of managers and foremen, whose assistance cannot by any means be dispensed with, and whose practical abilities must in every case conduce to the perfect accomplishment of engineering-work. And further, we do not forget that in many establishments the managers and employers are practical men, who give valuable practical assistance, and take an active part in the drawing-office work; the draughtsman acting, in some respects, under their instruction. The suggestions made by them, however, are often, from limit of time and other causes, necessarily of a broad nature; and it is left to the draughtsman, to use his ingenuity, practical knowledge, and powers of discrimination in "getting out" the details which, as a rule, constitute the most intricate and vital part of the work.

THE PATTERN-MAKER AND HIS TRADE.

Now, what do we mean by the term "pattern-maker"? One who puts theory into practice, by building a structure or model to be imitated. In order to do this successfully, he must understand the theoretical as well as the practical mechanism of the machine. He must understand a drawing as well as the man who made it; and also be able to make a drawing, if required to do so. He must thoroughly understand practical geometry, and be able to apply it to the different angles, curves and radii, as shown on the drawing. He must understand moulding as well as the foreman moulder. He must be familiar with the different wood-working machines in the shop, and be able to run them. He must know the nature and quality of all the different kinds

of wood required for the construction of the patterns. He must be a good, neat, clean and fast workman, and know the easiest, quickest, strongest and cheapest way to make all kinds of patterns. He must be able to impart this knowledge to others when required. In addition to all this, a good pattern-maker is a man who has what may be called forethought, and a practical knowledge with regard to the proper proportions and strength of materials of construction.

He should also have, I may say, an educated eye; for if any parts of a machine seem disproportioned, it is a sure sign that they should be corrected in some way. Thus unsuitable arrangements may be detected, and the expense of altering work avoided. The amount of labor and expense he may save in this way is almost incalculable, to say nothing of the more satisfactory results. The theoretical calculations of the strength of materials are, of course, useful: but they are, as a rule, very difficult in their application; and it often happens, that, when a pattern or a machine is made, it has a very different appearance from the design as represented on paper. It therefore follows, that, if time can be saved by the application of practical knowledge, an educated eye, and a little forethought (which costs nothing) on the part of the pattern-maker, the least possible expense will be the result.

I am here reminded that original thought is but little exercised, or even understood, by too many so-called mechanics, in all the different trades.

Now, I hold that manufacturers, superintendents, and foremen are largely to blame for this; and if they would only stop to consider the matter, and trace out cause and effect, they would find that this want of original

thought on the part of the workmen is not only detrimental to the interests of all concerned, but that they (the employers) have the remedy, principally, in their own hands; and while employers and managers of men have a right to expect the service of men's brains, as well as their hands, so the men have a right to expect that their employers will gladly and cheerfully accept that service. The man who says that if all mechanics were thinkers and inventors, there would be no use for such as he, simply makes a display of his own ignorance and lack of reasoning power. He, in fact, unwittingly takes off the mask in which impoverished thoughts ever array themselves, in the hope of giving mechanical emphasis to utterances which lack the impressiveness of argumentative force. Now, we cannot compel such a man to return to the abandoned field of logic, which he, at the outset, claimed exclusively as his; but we can, by force of reasoning, use him as an illustration of that class of employers who do not allow their men to think, and whose business suffers in consequence.

Fortunately, there is another and more numerous class of employers and foremen. They are men who will accept suggestions or advice when it is given to benefit their own pockets.

The superintendent or foreman who does not teach his men self-reliance, and who does not require them to do their own thinking in all matters appertaining to their trade, such as devising ways and means to accomplish their work to the best advantage and in the most economical manner, is not fit to hold a responsible position; and, in justice to himself, his employer and his fellow-workmen, he should step out, giving place to a more competent man.

THE ART OF MOULDING.

While many of the above remarks with regard to the pattern-maker and his trade are applicable to the moulder, there are some facts still remaining to be added.

"The fact is, the art of moulding — and it is an art — is never fully learned; and the oldest and most competent moulder will freely admit that he does not, and never expects to, know it all.

"I have stated that moulding was an art, and it is all I claim for it. I can say that there are moulders who have all the ardor of the artist; men whose trade is to them a thing of the heart, and who give their whole mind to their work. Such men are as rare, and as difficult to find as good civil engineers, draughtsmen, pattern-makers, painters, musicians, and engravers, but no more so. The moulder has sand, iron, coal, with their innumerable variations, to contend with in every new locality; and in many places the water he tempers his sand with affects the production of clear, sound castings." Still he has surmounted all these difficulties, and to the moulder the engineering world is indebted for material assistance in some of its greatest mechanical achievements.

Finally, while it is evident that the close connection which exists between pattern-makers and moulders renders their interests practically one, it is also obvious that both pattern-makers and moulders should understand drawing; and so, in order to attain a degree of proficiency in any one of these callings, we must have some knowledge of all.

CHAPTER II.

PATTERN-SHOP MACHINERY. — THE WOOD-TURNING LATHE.

There is no other machine-tool manufactured that is of so much value in the pattern-shop as the wood-turning lathe; and yet, generally speaking, there is no other which has received so little attention with regard to improvement, either from the constructors of wood-working machinery, or the purchasers of the same.

Now, there are some reasons for this seeming neglect. First, the high speed which is always necessary for wood-turning; and the number and variety of tools, and the many peculiar positions in which they have to be held in order to produce the fineness of finish required in pattern-work, and also to comply with other essential conditions, such as the direction of the grain, and the different kinds of wood used for the construction of patterns, render many of the improvements to be found on other wood-working machinery almost impracticable.

It must also be remembered, that a hand-tool can be sharpened in less time than it would take to remove the cutting-tool from a machine; and, as keenness of edge is one of the most essential conditions of a turning-tool, the time occupied in sharpening it is an important consideration. Notwithstanding all these impediments,

however, there is yet plenty of room for improvements in the pattern-maker's lathe, and much work is now done by hand that might be advantageously done by a machine properly designed.

Pattern-work, whenever possible, should have the benefit of accurate-working machinery, instead of hand-

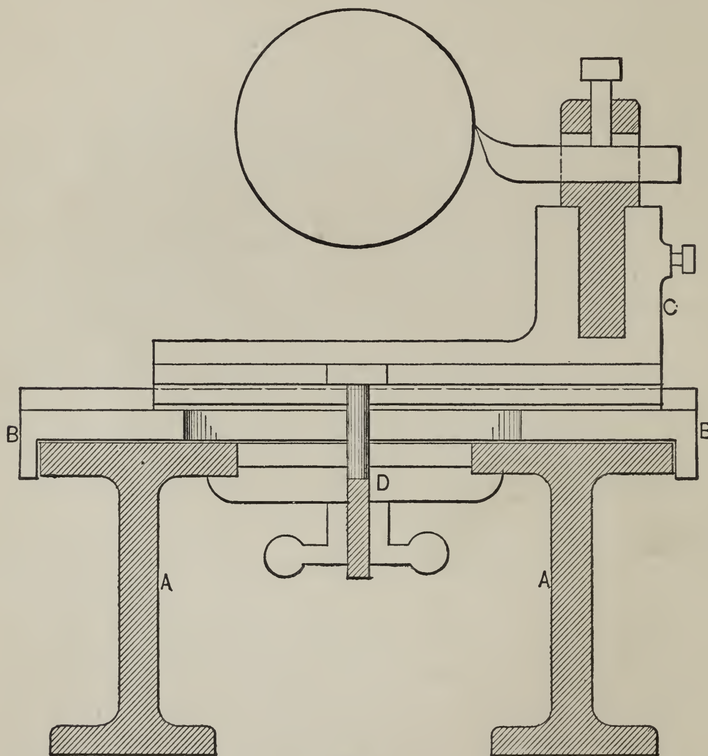


Fig. 1.

work; and a pattern-maker's lathe, fitted with a light slide-rest, as shown by the annexed cuts (Figs. 1, 2, and 3), would be a very useful tool. This, or any like attachment to any common wood-turning lathe, would

enable the pattern-maker to trim and face all kinds of straight work as true as with an engine-lathe; and by the addition of a swivel to the cross-slide, he could turn outside and inside bevels, tapers, etc.

Fig. 1 is an end-view of the attachment; Fig. 2 is a side-view; and Fig. 3 is a plan showing the lathe-shears, and the slide *B* with the cross-slide *C* removed.

A represents the lathe-shears; *B*, the slide-rest fitted on the ways to slide easily; *C*, the T-rest and tool-holder, sliding across the lathe on *B*.

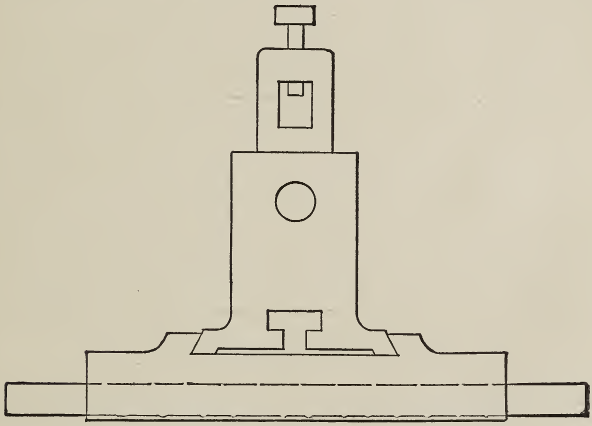


Fig. 2.

By inserting a block between the clamp *D* and the rest *B*, *C* is, of course, held firm for turning straight work, and *B* at the same time is allowed to slide (by hand) on the lathe-shears *A*.

A suitable tool for general use, in connection with the foregoing slide-rest, is shown at Fig. 4, and needs no further explanation.

Fig. 5 is a very good representation of an ordinary wood-turning lathe. Now, the following changes and

additions to this lathe would render it infinitely more valuable, at least for pattern-makers' use.

First, the shears should be made of iron, as shown at *A*, Fig. 1. Iron shears keep true, and the tailstock and tool-rest are more easily moved. Second, the cone should have five different speeds. Third, the position

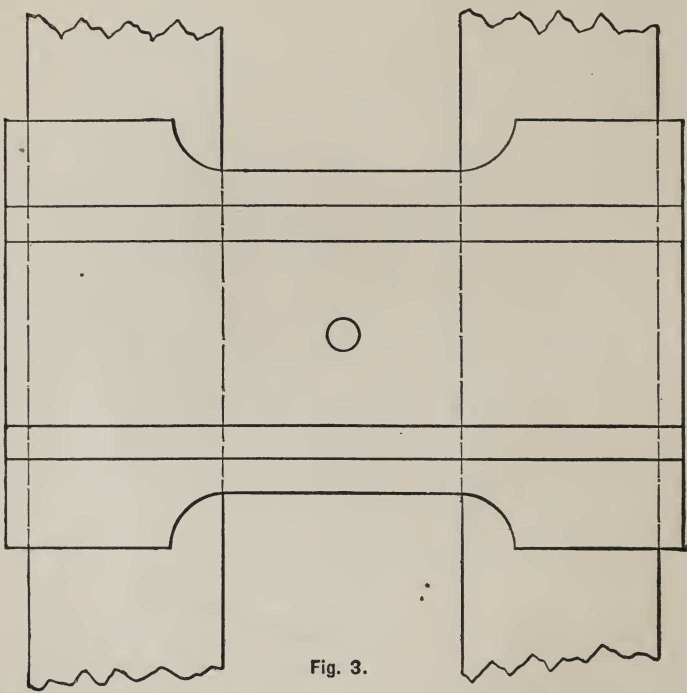


Fig. 3.

of the cone should be reversed; or, in other words, the small end of the cone should be set towards the centre of the shears, or tailstock. This is in order to let the workman have a chance to turn his job both back and face, without having to take it out of the lathe, and chuck it a second time before finishing. Of course,

this cannot always be done, but it can be in a great many cases. In its present position, however, the workman's hands, as well as the handle of the tool which he

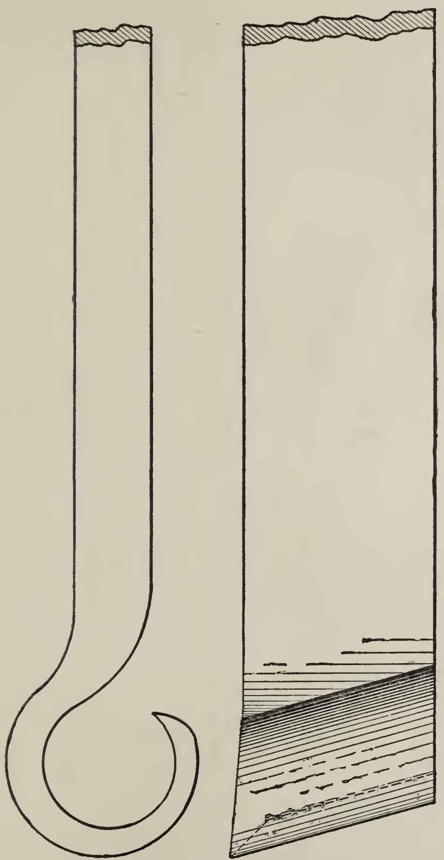


Fig. 4.

may chance to be using, are liable to come in contact with the large section of the cone. Fourth, in addition to the two face-plates shown in the figure, we should

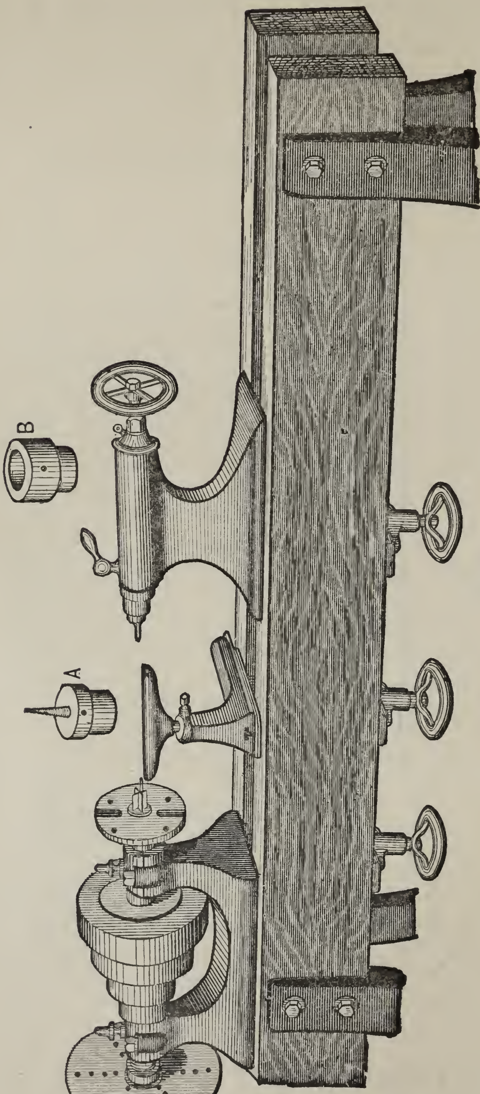


Fig. 5.

have two screw or worm chucks, and one box-chuck, such as shown at *A* and *B*. Fifth, the outside or overhanging end of the cone-spindle should be quite as large in diameter as the inside or driving end, because it is on the overhanging end of the lathe that all the heavy work is done, such as fly-wheels etc.; and so, of course, it should be very strong and rigid. In the jobbing-shop, or in any pattern-shop where iron or other metal patterns are frequently made, a good drill-chuck and a supply of small twist-drills will also be very useful.

THE BAND-SAW.

The utility of the band-sawing machine is too well known to require any lengthy elucidation in these pages; and when the table is provided with some such

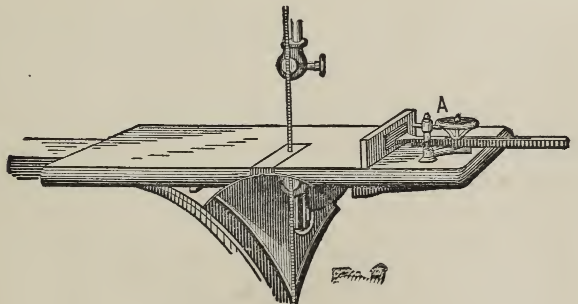


Fig. 6.

device as shown at *A*, Fig. 6, and also made adjustable so as to permit cutting upon any angle between the level and forty-five degrees, it is, practically speaking, a perfect machine tool, at least for pattern-makers' use.

The circular-saw table, if properly designed, is a great labor-saver in the pattern-shop, and is especially valu-

able for preparing stock for pattern-work, frequently effecting a saving of twenty-five or thirty per cent in material.

The circular-saw table, designed for pattern-work, should be made entirely of iron, and combine simplicity of arrangement with effectiveness. The table should be capable of universal adjustment, and provided with adjustable gauges for ripping and cross-cutting at any angle.

In addition to the common practice of ripping and cross-cutting, such a saw may be used for a great variety of purposes. By a proper adjustment of the gauges, grooves, shoulders and rabbets may be cut to any desired angle with almost perfect accuracy. Then again, if the gauge before mentioned, instead of being set parallel to the saw, is set obliquely to it, recesses may be sawed out, varying in elliptical form from a groove the width of the saw-kerf to a circle equal to the extreme diameter of the saw.

One of the most valuable and useful machine-tools yet produced for pattern-shop use is the buzz-planer, or jointing-machine. It bears about the same relation to the hand or bench-plane of the present day that the modern flooring-machines do to the old-fashioned tonguing and grooving planes. It performs its work with great accuracy, as well as with great rapidity; and for simplicity, durability, compactness, and general adaptation to all the different requirements of the pattern-shop, it has but few equals. Surface planing, jointing, bevelling, or cutting upon any angle whatever, are all performed with equal facility and accuracy; and but a few minutes are necessary to change from one class of work to another. It is especially

useful in getting out staves for cylinder work, segments for wheels, or other circles. In short, it is a good companion machine for the circular saw; and in any pattern-shop where three or four men are employed, these two machines will pay for themselves in less than a year. The two machines can be bought and set up ready for use for three hundred dollars. In a shop employing three or four men, these two machines will be worth as much as one good man. Now, suppose the man works three hundred days in the year, and receives $975 for his services, at the end of the first year we have a cash balance in favor of the saw and planer of $675, less the cost of power, oil, etc., $26.65; leaving a net balance of $658.35; and we have the two machines to boot, so to speak.

The above calculation looks reasonable to me; and I often wonder why so many shrewd business men continue to convert pattern-makers into circular-saws and buzz-planers.

Every pattern-shop should be provided with a good grindstone, and said stone should be kept in good condition. The old plan of letting pattern-makers worry along with tools ground on the stone in the machine-shop don't pay. The best workmen are always the men who have their tools in the best order, and they are the very men who detest going to grind them on a stone all cut and gouged out with cold-chisels and machine-tools. I don't believe the best workman that ever shoved a plane could do common justice to a respectable meat-axe on the average machine-shop grindstone.

CHAPTER III.

STANDARD PULLEYS.—DRAWING, PATTERN-MAKING, AND MOULDING.

In order to transfer motion, or force, from one axis to another, belt pulleys are undoubtedly the most universally employed; and, although the various circumstances of transmission render any fixed scientific principles or mathematical calculations with regard to dimensions impracticable, still some formula by which they may be drawn with such approximate correctness as to be sufficiently accurate for general purposes, is not only important but necessary.

Figs. 7, 8, and 9 exhibit the proportion of the different parts of pulleys, and the method of drawing pulleys having straight, curved, or S-shaped arms. The thickness of metal around the shaft, in the hub of any size of pulley, is measured as *B* on the line of the diameter of the pulley from the base line *A* to the line of the diameter of the shaft. The length of the hub is determined by adding the thickness of the web to twice the length of *E*, when measured from the base line *A* to the line of the face of the pulley on the line of the pulley's diameter, as shown at Fig. 7.

The arc which forms the outline of the drawing for the side of the arm is struck with a radius equal to three-fourths of the width, as shown at Fig. 8.

DRAWING.

The different forms of pulley-arms, and the method

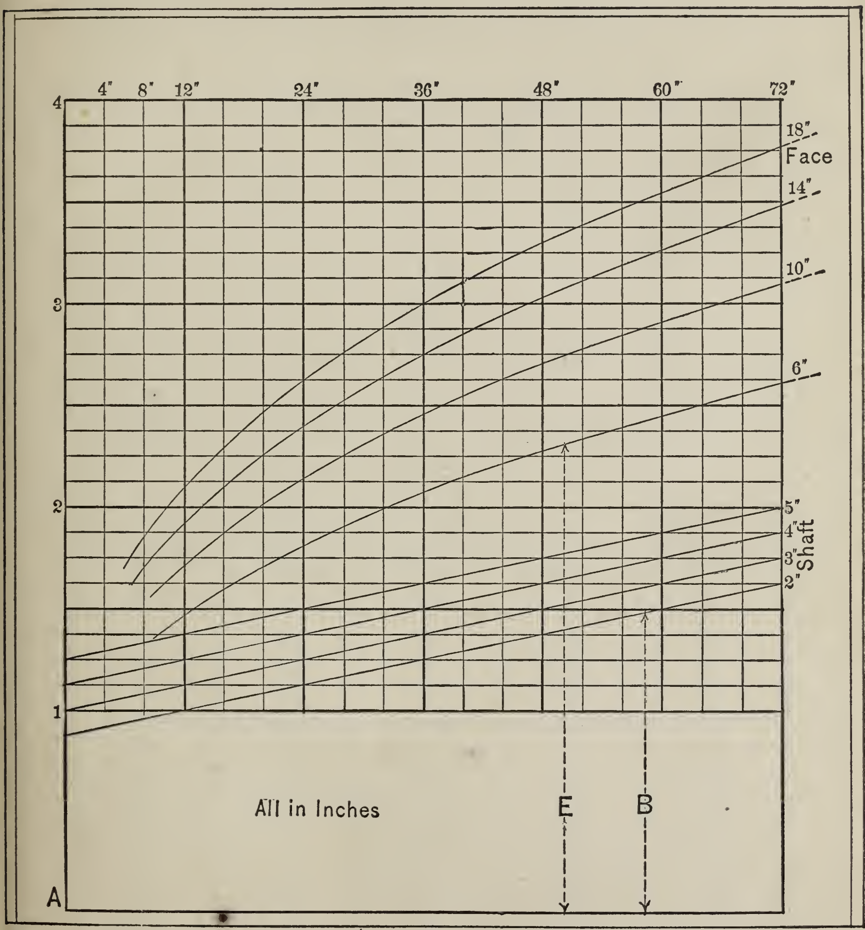


Fig. 7.

of drawing them, are shown at Fig. 9, and will be easily understood by the reader.

The width of the arm at the hub, and the thickness

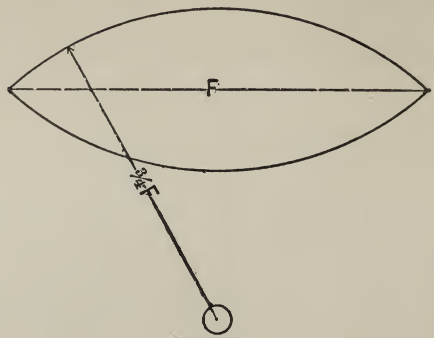


Fig. 8.

of the rim unfinished, will be found in the following tables: —

TABLE OF DIMENSIONS FOR STANDARD PULLEYS

From 6″ to 20″ inclusive, advancing by 1″.

Diameter of Pulley.	Width of Arm at Hub.	Thickness of Rim at Centre.	Thickness of Rim at Edge.	Width across the Web.
6″	1″	$\frac{5}{16}$″	$\frac{3}{16}$″	3″
7″	$1\frac{1}{16}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	3″
8″	$1\frac{1}{8}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	3″
9″	$1\frac{3}{16}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	4″
10″	$1\frac{1}{4}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	4″
11″	$1\frac{5}{16}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	4″
12″	$1\frac{3}{8}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	$5\frac{1}{4}$″
13″	$1\frac{7}{16}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	$5\frac{1}{4}$″
14″	$1\frac{1}{2}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	$5\frac{1}{4}$″
15″	$1\frac{9}{16}$″	$\frac{5}{16}$″	$\frac{3}{16}$″	$5\frac{1}{4}$″
16″	$1\frac{5}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$5\frac{1}{4}$″
17″	$1\frac{11}{16}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$5\frac{1}{4}$″
18″	$1\frac{3}{4}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$5\frac{3}{8}$″
19″	$1\frac{7}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$5\frac{3}{8}$″
20″	2″	$\frac{3}{8}$″	$\frac{1}{4}$″	$5\frac{3}{8}$″

TABLE OF DIMENSIONS FOR STANDARD PULLEYS

From 22″ to 72″ inclusive, advancing by 2″.

Diameter of Pulley.	Width of Arm at Hub.	Thickness of Rim at Centre.	Thickness of Rim at Edge.	Width Across the Web.
22″	$2\frac{1}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$6\frac{1}{4}$″
24″	$2\frac{1}{4}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$6\frac{1}{4}$″
26″	$2\frac{3}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	$6\frac{1}{4}$″
28″	$2\frac{1}{2}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	7″
30″	$2\frac{5}{8}$″	$\frac{3}{8}$″	$\frac{1}{4}$″	7″
32″	$2\frac{3}{4}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	7″
34″	$2\frac{7}{8}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	7″
36″	3″	$\frac{7}{16}$″	$\frac{5}{16}$″	8″
38″	$3\frac{1}{8}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	8″
40″	$3\frac{1}{4}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	8″
42″	$3\frac{3}{8}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	8″
44″	$3\frac{1}{2}$″	$\frac{7}{16}$″	$\frac{5}{16}$″	9″
46″	$3\frac{5}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	9″
48″	$3\frac{3}{4}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	9″
50″	$3\frac{7}{8}$″	$\frac{1}{2}$″	$\frac{3}{8}$″	10″
52″	4″	$\frac{1}{2}$″	$\frac{3}{8}$″	10″
54″	$4\frac{1}{8}$″	$\frac{9}{16}$″	$\frac{7}{16}$″	10″
56″	$4\frac{1}{4}$″	$\frac{9}{16}$″	$\frac{7}{16}$″	11″
58″	$4\frac{3}{8}$″	$\frac{9}{16}$″	$\frac{7}{16}$″	11″
60″	$4\frac{1}{2}$″	$\frac{9}{16}$″	$\frac{7}{16}$″	11″
62″	$4\frac{5}{8}$″	$\frac{5}{8}$″	$\frac{1}{2}$″	11″
64″	$4\frac{3}{4}$″	$\frac{5}{8}$″	$\frac{1}{2}$″	12″
66″	$4\frac{7}{8}$″	$\frac{5}{8}$″	$\frac{1}{2}$″	12″
68″	5″	$\frac{5}{8}$″	$\frac{1}{2}$″	12″
70″	$5\frac{1}{8}$″	$\frac{5}{8}$″	$\frac{1}{2}$″	$12\frac{1}{2}$″
72″	$5\frac{1}{4}$″	$\frac{5}{8}$″	$\frac{1}{2}$″	$12\frac{1}{2}$″

TO DRAW THE STRAIGHT ARMS.

First draw the circle representing the extreme diameter of the pulley, then draw the circle for the inner edge of the rim; on this circle set off six points, and from these points draw radii lines to represent the centre

of the arms. Next strike the circles indicating the bore of the pulley and the outer edge of the hub; then on each side of the radii or centre of the arm, on the circles of the diameter of the hub and inside edge of the rim, set off points to denote the width of the arm at the hub and rim, and from these points draw lines to show the edge of the arms. The arms should not meet the rim in a sharp corner, as shown in this small illustration, but the straight lines are joined to the circle by means of a small arc, which may be drawn to any size pleasing to the eye. In like manner, the arms at their base are united by an arc, which should be struck with a radius from some point on a line bisecting their angle.

These curves should not again form angles at the points where they meet the straight lines, but should be so drawn as to touch the line of the web, and then merge imperceptibly into the straight lines indicating the edge of the arms.

TO DRAW CURVED ARMS.

On the circle of the outer edge of the rim, locate the point *L* for the centre of the arm; then, with a radius equal to two-thirds of the radius of the pulley, draw the circle *A*, and from a point somewhere on this circle, with the same radius, strike the arc, bisecting the point *L* and the centre of the hub; and on each side of this arc, on the lines of the diameter of the hub and the inside edge of the rim, set off points to denote the width of the arm at the rim and base.

We now add half the width of the arm at *F* to the former radius, and draw the arc *a*, bisecting the proper points on the diameter of the hub and inner edge of the rim. Then from the present radius take the full

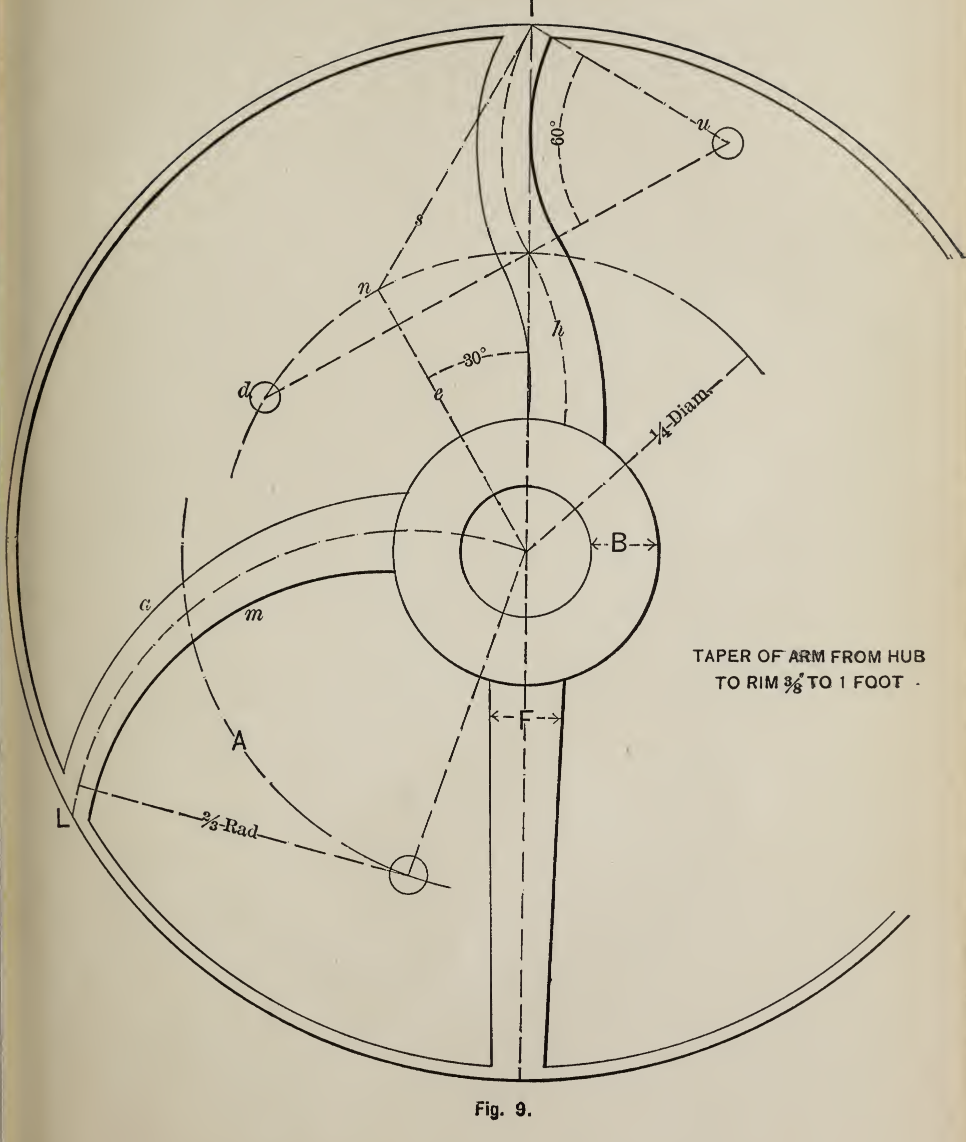

T
u
60°
s
n
h
30°
d
e
¼-Diam.
B
c
m
TAPER OF ARM FROM HUB
TO RIM ⅜″ TO 1 FOOT
F
A
L
⅔-Rad

Fig. 9.

width of the arm at *F*, and draw the arc *m*, and thus produce a complete outline of the arm.

In this, as in all other forms of arm, the corners, as points of intersection at the hub and rim, should, of course, be filleted as mentioned when describing the method of drawing the straight arms.

TO DRAW THE S-ARM.

From the point *T* on the diameter, draw radii; then, with a radius equal to one-quarter of the diameter of the pulley, strike the circle *n;* and on this circle, from its intersection with the radius *T*, at a distance equal to its radius, set off the point *d*. At an angle of thirty degrees from the radius *T*, we draw the line *e*, cutting the circle *n* and the centre of the hub. From the intersection of *n* draw the line *s*, joining *e* and *T*. From the point *T*, at right angles with *s*, draw the line *u*, join *d* and *u*, cutting the circle *n* at the radius *T*. With the points *d u* for centres, draw the line *h*, which will represent the centre line of the arm. From this line set off the width of the arm, the hub, the centre, and rim, and then with the proper radii draw the outlines of the arms, as shown in the figure.

It frequently happens that pulleys are required to

Fig. 10.

have extra heavy arms; and under such circumstances the following table of dimensions, and the form of arm

shown at Fig. 10, have been found good, and give perfect satisfaction when used in connection with the described method of drawing.

TABLE OF DIMENSIONS OF STANDARD PULLEYS,

Having extra heavy arms, from 6″ to 60″ inclusive, advancing by 2″.

Diameter of Pulley.	Thickness of Rim.	Thickness of Arm at Rim.	Thickness of Arm at Hub.
6″	$\frac{5}{32}''$	$\frac{15}{16}'' \times \frac{5}{16}''$	$1\frac{1}{4}'' \times \frac{1}{2}''$
8″	$\frac{5}{32}''$	$1'' \times \frac{3}{8}''$	$1\frac{3}{8}'' \times \frac{5}{8}''$
10″	$\frac{3}{16}''$	$1'' \times \frac{3}{8}''$	$1\frac{3}{8}'' \times \frac{5}{8}''$
12″	$\frac{3}{16}''$	$1\frac{1}{16}'' \times \frac{7}{16}''$	$1\frac{7}{16}'' \times \frac{5}{8}''$
14″	$\frac{3}{16}''$	$1\frac{1}{16}'' \times \frac{7}{16}''$	$1\frac{7}{16}'' \times \frac{5}{8}''$
15″	$\frac{3}{16}''$	$1\frac{1}{16}'' \times \frac{7}{16}''$	$1\frac{7}{16}'' \times \frac{5}{8}''$
16″	$\frac{3}{16}''$	$1\frac{1}{4}'' \times \frac{7}{16}''$	$1\frac{1}{2}'' \times \frac{11}{16}''$
18″	$\frac{1}{4}''$	$1\frac{3}{8}'' \times \frac{7}{16}''$	$1\frac{5}{8}'' \times \frac{11}{16}''$
20″	$\frac{1}{4}''$	$1\frac{3}{8}'' \times \frac{1}{2}''$	$1\frac{3}{4}'' \times \frac{11}{16}''$
22″	$\frac{1}{4}''$	$1\frac{3}{8}'' \times \frac{5}{8}''$	$2'' \times \frac{7}{8}''$
24″	$\frac{1}{4}''$	$1\frac{7}{16}'' \times \frac{11}{16}''$	$2\frac{1}{8}'' \times \frac{15}{16}''$
26″	$\frac{1}{4}''$	$1\frac{1}{2}'' \times \frac{11}{16}''$	$2\frac{1}{8}'' \times \frac{15}{16}''$
28″	$\frac{5}{16}''$	$1\frac{5}{8}'' \times \frac{11}{16}''$	$2\frac{1}{4}'' \times 1''$
30″	$\frac{5}{16}''$	$1\frac{3}{4}'' \times \frac{3}{4}''$	$2\frac{3}{8}'' \times 1''$
32″	$\frac{5}{16}''$	$2'' \times \frac{7}{8}''$	$2\frac{5}{8}'' \times 1\frac{1}{8}''$
34″	$\frac{3}{8}''$	$2\frac{1}{8}'' \times \frac{7}{8}''$	$2\frac{3}{4}'' \times 1\frac{1}{8}''$
36″	$\frac{3}{8}''$	$2\frac{1}{2}'' \times \frac{15}{16}''$	$3'' \times 1\frac{1}{4}''$
38″	$\frac{7}{16}''$	$2\frac{5}{8}'' \times \frac{15}{16}''$	$3\frac{1}{8}'' \times 1\frac{1}{4}''$
40″	$\frac{7}{16}''$	$2\frac{3}{4}'' \times 1$	$3\frac{1}{2}'' \times 1\frac{5}{16}''$
42″	$\frac{1}{2}''$	$3\frac{1}{4}'' \times 1\frac{1}{8}''$	$4'' \times 1\frac{3}{8}''$
48″	$\frac{1}{2}''$	$3\frac{1}{2}'' \times 1\frac{7}{16}''$	$4\frac{1}{2}'' \times 1\frac{13}{16}''$
52″	$\frac{9}{16}''$	$3\frac{5}{8}'' \times 1\frac{1}{2}''$	$4\frac{3}{4}'' \times 1\frac{7}{8}''$
60″	$\frac{5}{8}''$.	$3\frac{3}{4}'' \times 1\frac{9}{16}''$	$5\frac{1}{4}'' \times 2''$

PATTERN–MAKING.

Among the many methods of making standard pulley patterns, and moulding the same, I believe the following is the best: —

Make an iron pattern of rim, the diameter of pulley

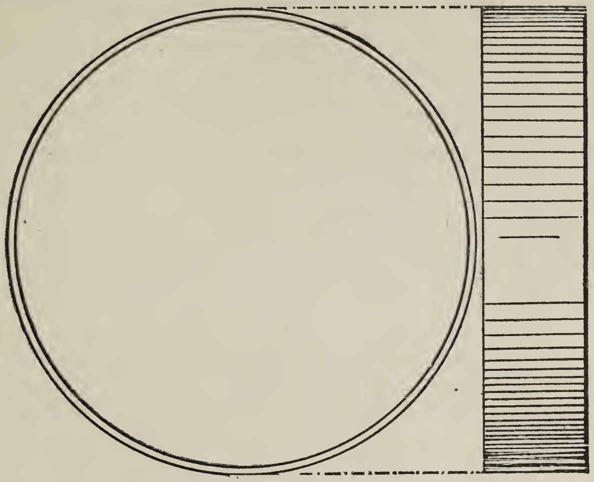


Fig. 11.

required, and from 6″ to 8″ face. (See Fig. 11.) Now

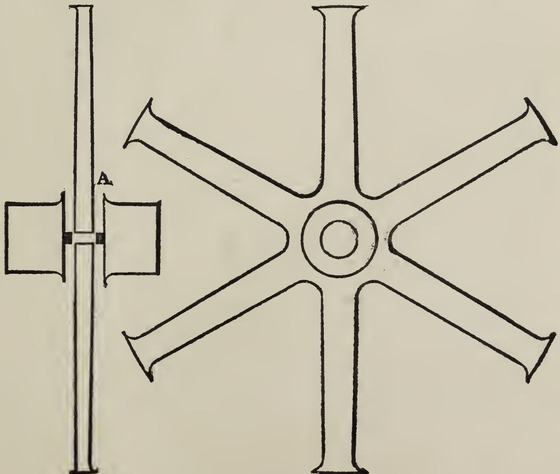


Fig. 12.

make iron pattern of arms as shown at Fig. 12. The

arms should be an easy fit when put in place, say one-sixteenth slack. Drill a 1″ hole in centre for hub-dowel, as shown at *A*, Fig. 12. Make a set of wooden patterns for all the different sizes of hubs required. Hubs should have a 1″ hard-wood dowel-pin in the bottom of each, so that they will fit any size of pulley.

MOULDING.

Fig. 13 is a core or lifting-plate, made to fit between

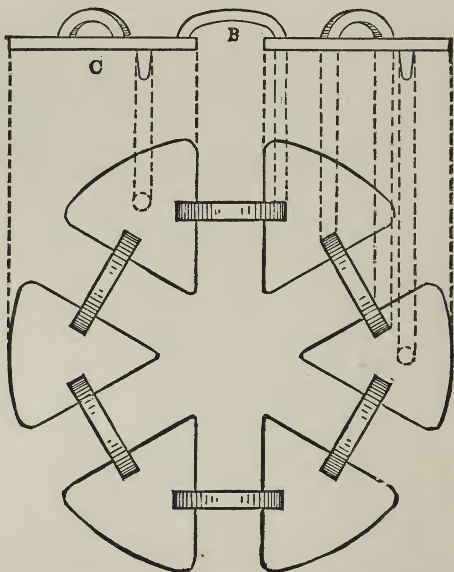


Fig. 13.

the arms, leaving a margin of about $\frac{5}{8}$″ between the edge of the plate and the pattern. The different sections are connected by a strong bridge, as shown at *B*. Three or four of the sections should have a large and pointed dowel, or guide-pin *C*, cast on bottom.

Fig. 14 shows the rim moulded on the outside, and the arms and hubs set in position and moulded up to the

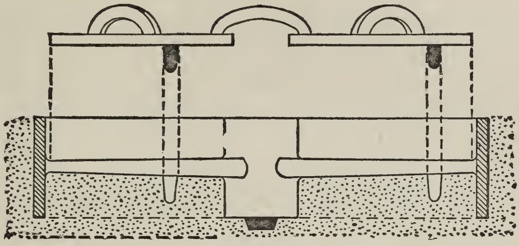


Fig. 14.

centre. The core or lifting-plate, Fig. 14, is now set in place, and bedded down solid, as shown at Fig. 15. The

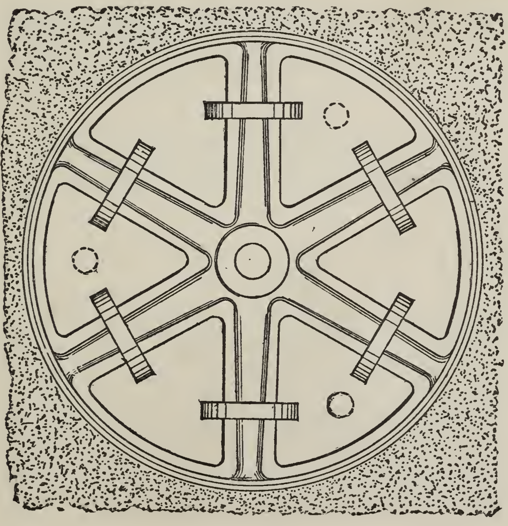


Fig. 15.

parting can now be made, and the centre filled in and rammed up level with top of mould. We are now

ready to put on cope-flask *E*, Fig. 16; fill in, ram up, and make gate in same.

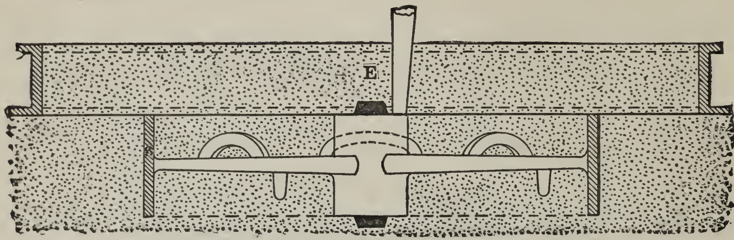


Fig. 16.

We can now lift off cope *E*, and draw the rim pattern; then lift away the centre, and draw from the sand the patterns of arms and hub. Finish the mould, and set

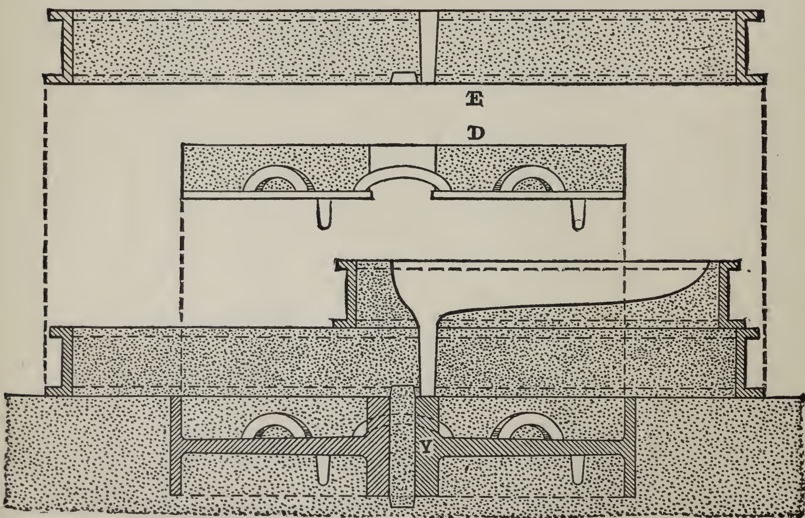


Fig. 17.

centre *D*, Fig. 17, back into position; close down cope *E*, make runner, and it is ready to cast, as shown at Fig. 17.

CHAPTER IV.

MOULDING LARGE INTERNAL FLANGED PULLEYS WITHOUT A PATTERN.

NEARLY every jobbing and machine foundry, and pattern-shop also, has something to do with pulley-

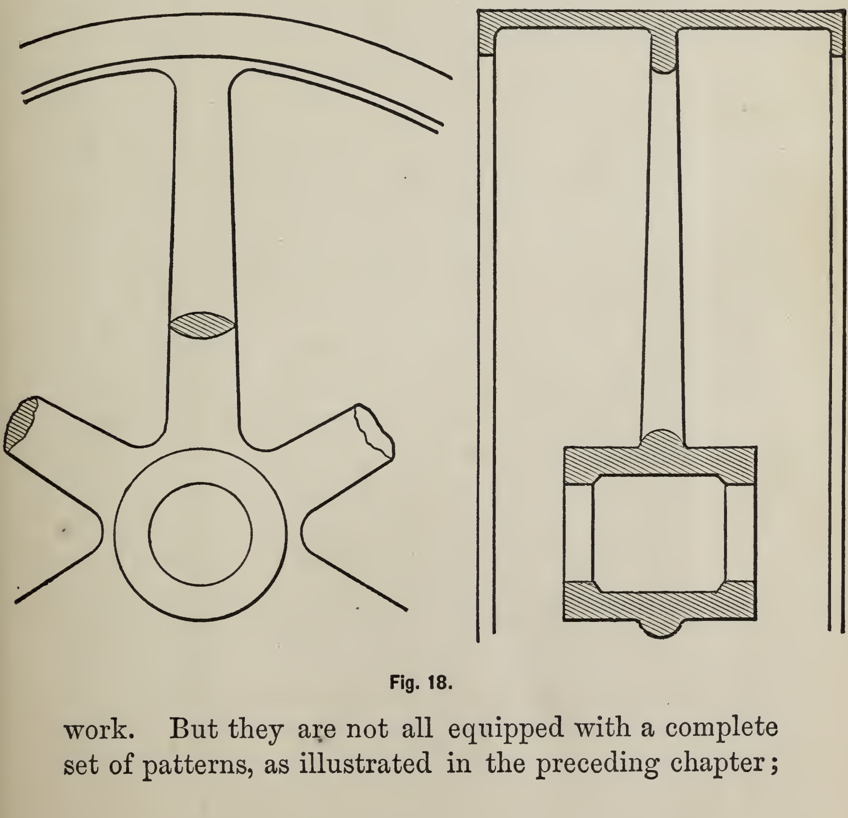


Fig. 18.

work. But they are not all equipped with a complete set of patterns, as illustrated in the preceding chapter;

and, even in those establishments where pulley-work is considered a specialty, they are not provided with a pattern for every form and size of pulley: in fact, such a thing would be almost impossible.

Suppose a man comes along with a sketch of a pulley such as is shown at Fig. 18. This pulley must be 6 feet in diameter, 14″ face, and be bored to fit a $3\frac{1}{2}''$ shaft. The peculiar circumstances, and conditions with regard to the position in which this pulley has to be placed, as well as the speed at which it has to move, call for the casting to be as light as possible; reference, of course, being had to strength, and the force to be transmitted. Few shops have standard patterns on hand that would fill the bill for such an order; and to make a full pattern would cost more than the customer would be willing to give for the whole job.

By the system herewith illustrated, pulleys of any diameter or width of face can be moulded in either green or dry sand, or loam, with but little expense for pattern-making.

Fig. 19 is a plan and side sectional elevation of the core-box for forming the hub-arm and inside of the rim. The depth of this box, when finished, must be equal to one-half the width of the face of the pulley, and must taper from one-sixth of the circumference of the inside of the rim of the pulley to the centre of the hub, as shown in the figure. The arc which forms the rim of the pulley should be equal in depth to half the width of the face of the pulley, less the thickness of the flange and fillet. On the top edge of this arc we set the loose segment shown at *A*, which will form the fillet, and project over for the flange, as shown at *B*. A half section of the centre bead, on the inside of the rim of

the pulley, and also a section of the arm and hub, must be set on the bottom, in the positions shown at *C* and *D*. The whole end or arc of the box should be made loose, and held in place with stout screws; then, when the core has been made, and is ready to lift out of the

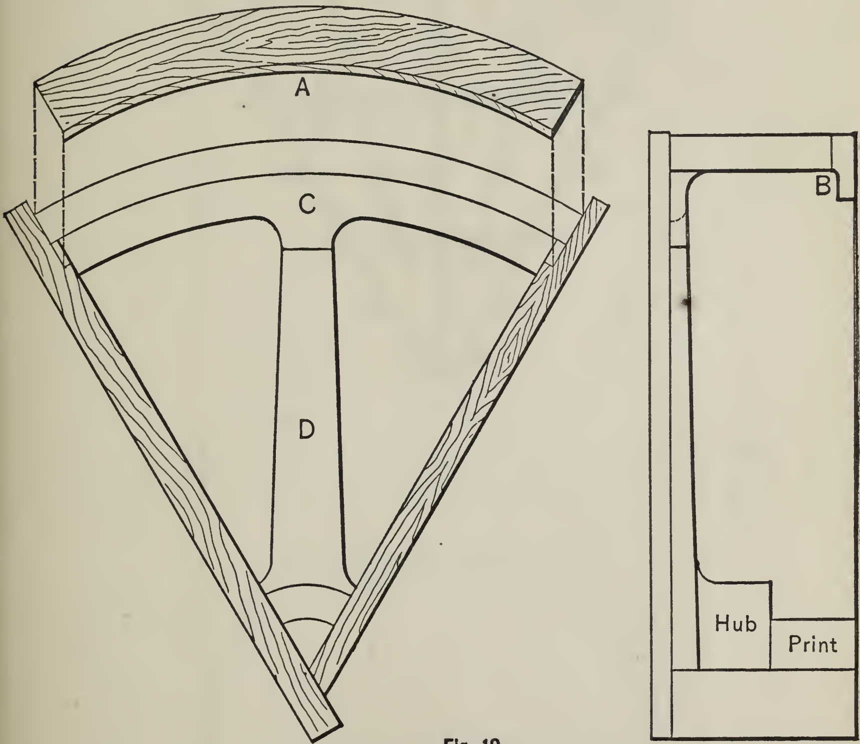


Fig. 19.

box, the screws can be taken out, and the end removed, and thus avoid all danger of breaking the core.

A plan of the core-frame is shown at Fig. 20. The circles, Nos. 1, 2, and 3, indicate the location of the holes or staples for inserting the hooks or lifting-irons.

Fig. 21 is a plan of the box for making cake cores, which are used for covering the edge of the rim of the pulley, as shown at *E*, Fig. 22. This box is a plain

Fig. 20.

frame, either screwed or nailed together, and open at both top and bottom. It should be about two inches

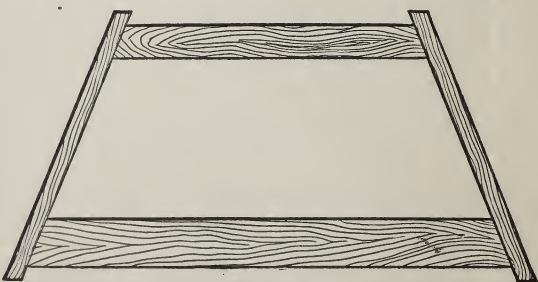
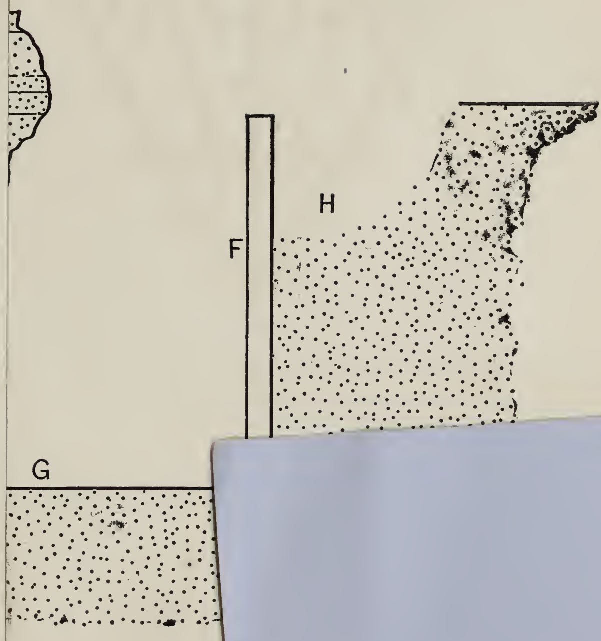


Fig. 21.

deep, and may be made to any convenient length, providing a number of full cores will make a complete circle of the rim without cutting.


H
F
G

In addition to the two core-boxes illustrated above, it is well to make a segment for the outside of the rim of the pulley. It is not necessary for this segment to be finished to any particular size; but it should have a straight surface, parallel with the face, so that it may be used for the purpose of plumbing and setting the segment true when moulding, as shown at *F*, Fig. 22.

MOULDING.

The cut (Fig. 22) showing half section of the mould, with all the cores set and the cope closed down, represents the mode of sweeping or moulding this style of pulley in green-sand and dry-sand cores. The cut shows a hole dug in the floor to the depth of face required plus the thickness of the cake core shown at *E*. The bottom of this excavation is then rammed solid, and swept off level and smooth, as shown at *G*. On this level surface we strike a circle — the diameter of the pulley — to serve as an approximate guide for setting the segment *F*. When the bottom of the mould has been swept off true, and the circle struck as described, we set the segment *F* to the line of the diameter of the pulley, as shown. It is then held firmly in place with strong braces from the centre of the mould. We then fill in the sand, and ram up the outside level with the top edge of the segment, as shown in part at *H*. The segment is then moved around to the next position, and moulded on the outside as before, continuing the operation until a complete circle of the rim has been made. When the outside of the rim has been thus formed and finished, we are ready to set the hub core as shown in the figure.

The cut shows one set of cores resting on the bottom

or bed of the mould. A part of the space below the hub core may, in some cases, be filled up with green sand in order to shorten the bottom end of the hub core as shown at *J*.

When the bottom set of cores is placed in position, the top set can be put on without any trouble, and the joints of the cores made tight to avoid fins on the casting. The rim of the pulley is then covered with the cake cores *E*, the hub core set in place, and covered with a cake core, as shown. We are then ready to close down the cope, put on the necessary weights, and cast the pulley.

For large sized pulleys, it is well to discard the segment *F*, and build up the outside of the rim with loam, as it will be much smoother, and gives a better appearance to the casting.

CHAPTER V.

MOULDING DOUBLE-ARMED PULLEYS AND DRUMS IN GREEN SAND, DRY SAND, AND LOAM.

WE now come to speak of double-armed pulleys, and will take for an example a large drum for an elevator engine. This class of work can be made in green sand, dry sand, or loam, as circumstances may determine, and either with a full pattern or with sweeps and cores.

MOULDING WITH A FULL PATTERN.

For large sizes, or when the body of the pattern is too heavy to turn in an ordinary wood-turning lathe, it may be made in two pieces, and then fastened together with three strong bolts. These bolts can also be made to do duty as draw-irons. In the present example, the projection or ring *A* (Fig. 25) was made loose, as was also the flange *B*. The openings *C* between the arms and at each side of the ring *A* are made with cake cores.

The body cores are made in twelve sections, six upper and six lower. When making the body core-box, the same principle is involved as illustrated by Fig. 19, in the preceding chapter. After making the proper excavation in the floor of the foundry, we put in a layer of cinders three or four inches thick; then five or six inches of sand; then set the ring *A*, fill in, and ram up level with the top. This part of the mould must be

well vented downward to the cinders, which will take away all the gas from the bottom of the mould by way of the two three-inch pipes, as shown at Fig. 25. Now

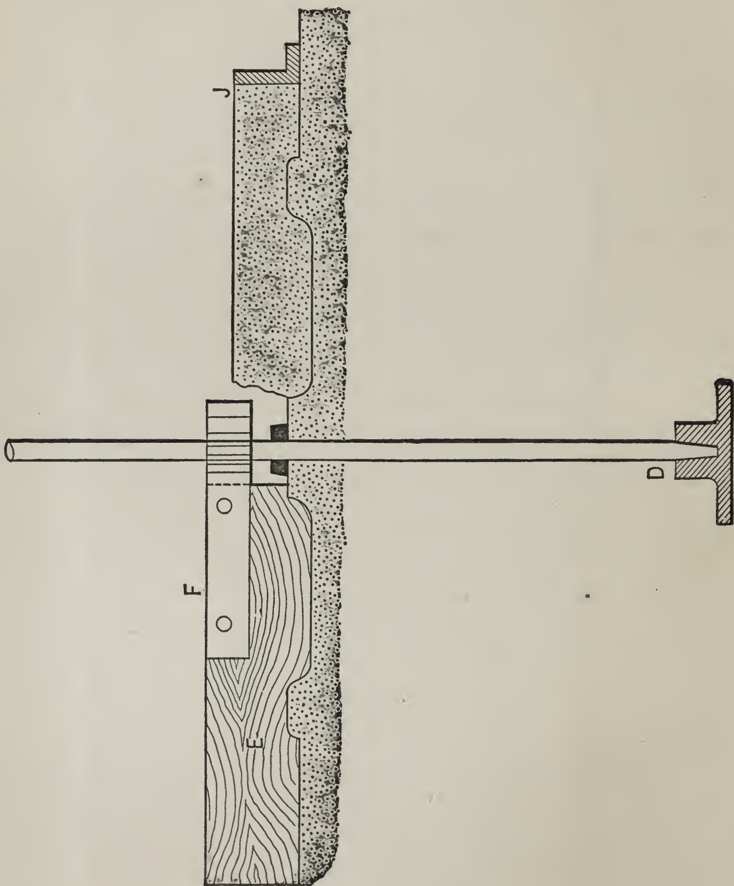


Fig. 23.

set on the body of the pattern, and then place and mould the segments of flange *B*, and make the parting at centre of same. When this is done, set the main

part of the flask, fill in, mould up to the top of the flange, and make parting along the top of the pattern. Put on cope part of flask, fill in, ram up, and make three $1\frac{1}{2}$-inch feed-gates and four $1\frac{1}{8}$-inch risers. When this is done, lift off the cope, and draw from the sand the body of the pattern. Then lift away the main part of the flask, and draw the flange *B* and ring *A*. The cores are then put in position as follows: First set the bottom or ring core, and then the twelve cake cores *C*. Now set the six lower sections of the body core, make joints, etc. This being done, set the upper sections of body core. The upper and lower body cores are set to half lap each other. Set hub core, and finish the mould. Close it up, and make feed channel.

MOULDING WITH SWEEPS AND LOAM.

At Figs. 23 and 24 we have shown the method of making a similar casting with sweeps and loam.

Having set the step *D*, and the spindle shown in Fig. 23, we get the strickle-board *E*, and bolt it to the arm *F*. With this we sweep off the form of the top of the mould or bottom of the cope, and on the surface so formed set the flask *J*, and mould it up as shown; then lift it off, and dry it in the most convenient manner. We now make a hole in the floor of the foundry, and put in a layer of cinders three or four inches thick, set the vent-pipes shown at Fig. 24, and then fill the hole up with sand. We now put a cast-iron ring, with an inside diameter about two inches larger than the extreme diameter of the drum or pulley, and from seven to ten inches wide, and bed it in the floor, as shown at *L*. This ring makes a good bearing-surface for the brick-work, as well as a guide for the point of the

sweep-board *T*. The lifting-plate *R* may now be put on,

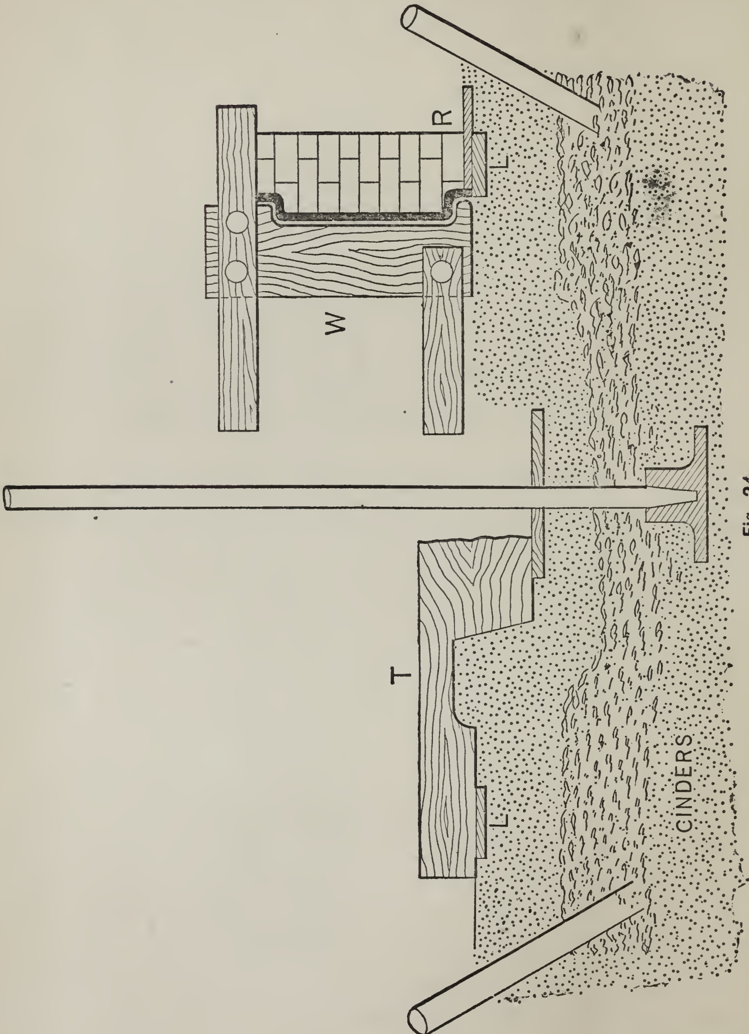


Fig. 24.

and the brick-work built up, as shown, using the sweep

W for a guide. When the outside of the drum or pulley has been thus built up in loam, it is hoisted off

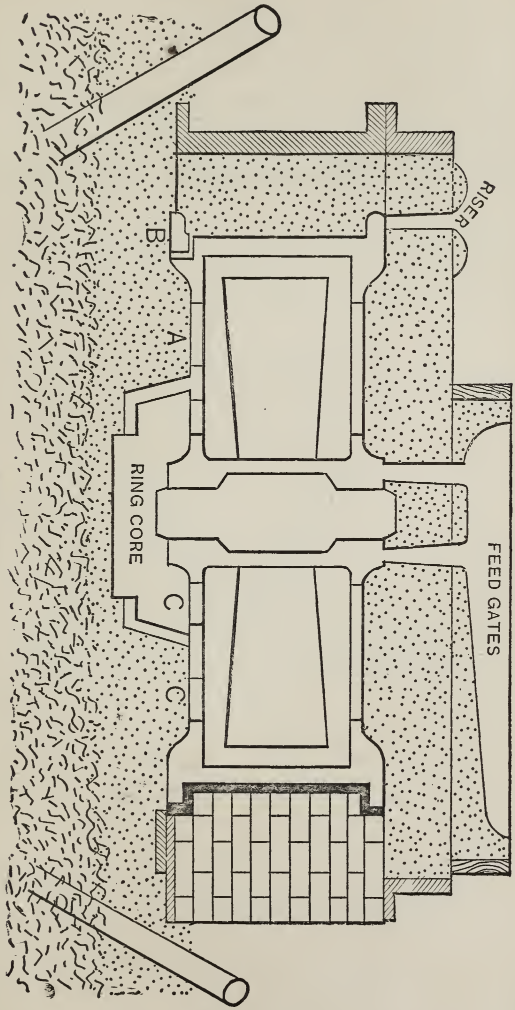


Fig. 25.

and dried, while the bottom and inside are being

moulded. The strickle-board *T* is then bolted to the spindle-arm; and with it the bottom of the mould can be swept out to shape, using the core print and cast-iron ring *L* for a guide as to depth.

When the bottom of the mould has been formed and finished, the cores may be set in the same order as for green-sand moulding, the loam-work lowered to position, the mould closed, and made ready to cast, as shown at Fig. 25.

CHAPTER VI.

MOULDING LARGE GEAR-WHEELS.

For the transmission of power by machinery, gear-wheels are frequently brought into action, and for standard work may be considered next in order to pulleys.

Now, the manner of moulding any ordinary gear, where we have a complete pattern, is too well known

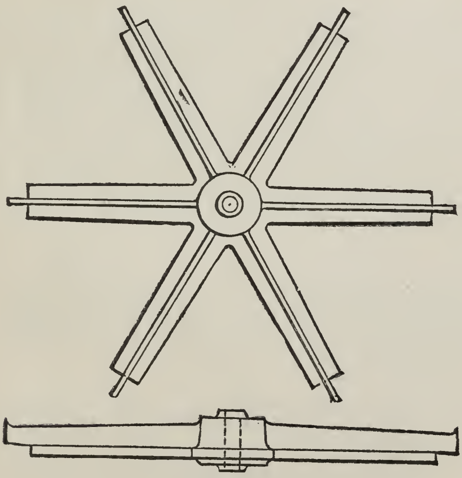


Fig. 26.

to require any notice in these articles. But suppose a special order comes in, and we want a gear-wheel 10 or 12 feet in diameter, $2\frac{1}{2}''$ pitch, and $9''$ face. The quick-

est and best way to make such a wheel is often of more than usual importance, and to make a full pattern is entirely out of the question.

From among the various ways of making such wheels I have selected the following, which I will try to illustrate.

Fig. 26 is the plan and elevation of a set of arms, for which, in many cases, it is advisable to make a full pattern.

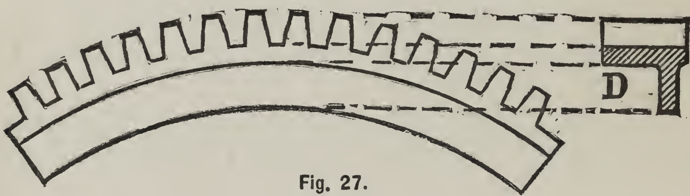
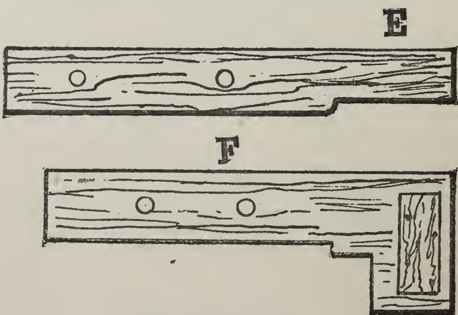


Fig. 27.

Fig. 27 shows a segment of the rim of the wheel, and a number of teeth attached. If the distance is not too great, it is well to make this segment long enough to take in two arms, as shown in Fig. 33. This, however, is not of much importance, as from fifteen to twenty teeth are generally a sufficient number.



Figs. 28 and 29.

Figs. 28 and 29, or *E* and *F*, are "strickle" boards,

the utility of which will be seen when we come to the moulding part of our work. The face of the strickle-board *E* is made to fit the top of the rim at A, Fig. 32, and that of *strickle F* is the form of the inside of the rim at *D*, Fig. 27.

Now, if we are pushed for time in the pattern-shop, or if for any other reason it is not convenient to make

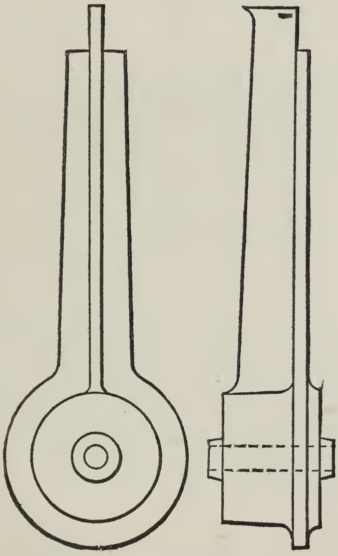


Fig. 30.

a pattern for a full set of arms, as mentioned above, we should make a pattern of the hub and one arm, as shown at Fig. 30. In either case the hub and print must have a hole through the centre to fit the spindle used in the foundry.

MOULDING.

Having prepared the floor, and set the spindle-step or bearing, we bed down the arm-pattern, and mould it up level with the top. We now take the strickle-board *E*, and bolt it to the arm of the spindle, as shown at *C*, Fig. 31. This will scrape off the top of the mould level

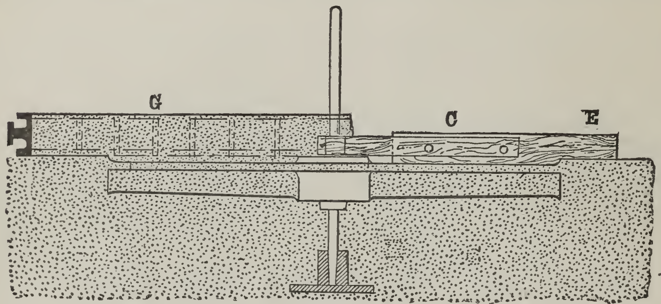


Fig. 31.

with the pattern, and leave the correct form for the bottom of the cope and top of the rim.

We now take off the strickle, make parting, lay on the cope-flask, as shown at *G*, Fig. 31, ram it up, and

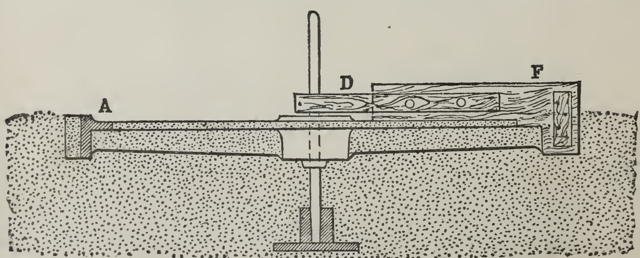


Fig. 32.

lift it off again. This being done, take strickle-board *F* and bolt it to arm of spindle, as shown at *D*, Fig. 32. With this scrape away the sand around the outside of

the arms, leaving a level and smooth bottom for segment of rim and teeth. Having done so, set pattern of segment in position, and press it down hard enough to leave the impression of the ends of the teeth in the sand; or, what is perhaps better, shake a little flour between the teeth. Then lift it, and move it around from place to place until the circle is completed. Should

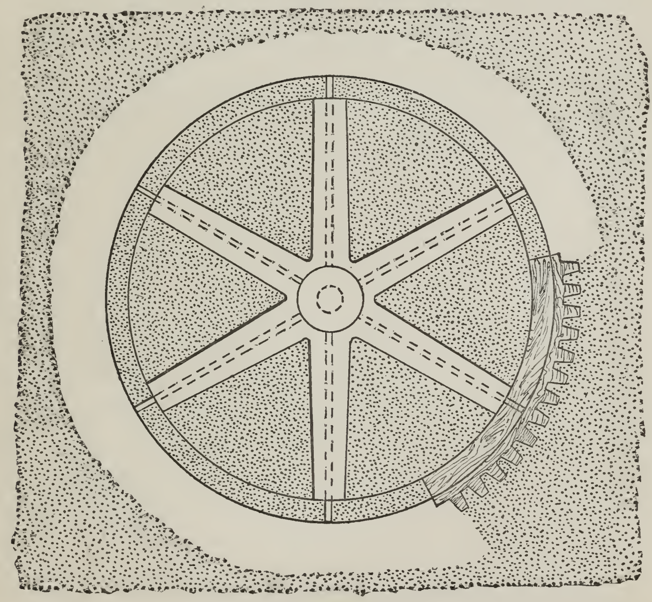


Fig. 33.

it fall short, or overreach a little in the circumference, it can be adjusted by a slight change in the diameter of the wheel. Having thus decided on the correct position for it, we set the segment, and ram up the teeth, as shown at Fig. 33. Then draw it from the sand, and move it around to the next position, ram it up again, and so on until the circle is completed. Then draw

from the sand the pattern of the arms, finish, and close the mould.

When the pattern of hub and one arm is used instead of the full set of arms, as mentioned above, we must first take the strickle-board *E*, and scrape off the top of the mould, make parting, set on cope-flask *G*, ram it up, and lift it away again. Then use strickle-board *F*, as shown at *D*, Fig. 32. Bed in and mould the hub and arm; then draw it from the sand, and move it around to the next position; ram it up again, etc., until finished. You are then ready to use the segment of rim and teeth as before.

CHAPTER VII.

WORM GEAR. — DRAWING, PATTERN-MAKING, AND MOULDING.

I THINK it was Josh Billings who said, "Some people spend a great deal of time trying to twist the untwistable, when they might as well sit down in a washtub, take hold of the handles, and try to lift the unliftable."

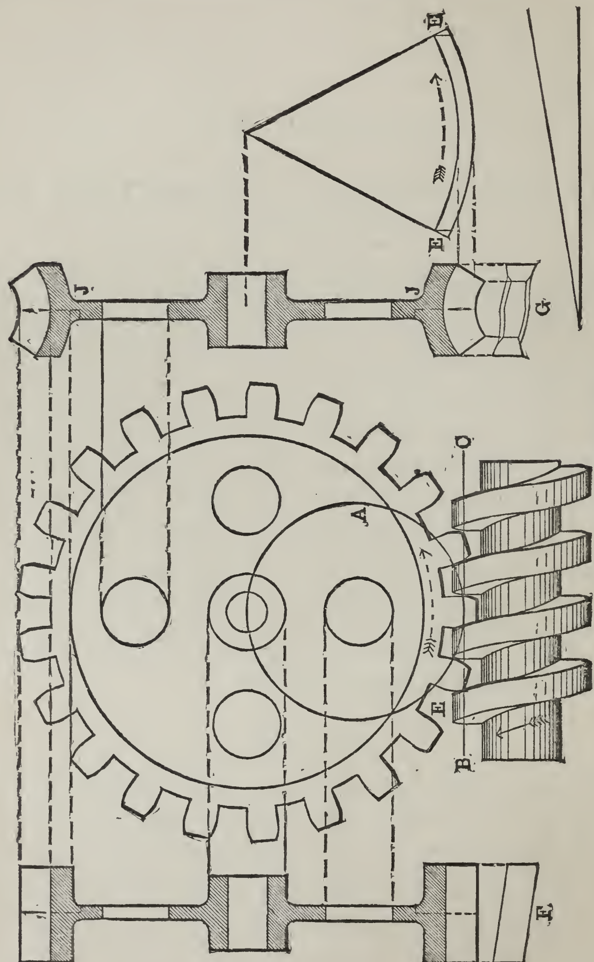
Now, this worm gear is a twisted question, and one in which Josh's words have been almost verified, as it has been the cause of more discussion with regard to the proper method of drawing, pattern-making, and moulding the same, than any other form of gear.

In consideration of this fact, I think the following, which has been proved to be good, will be of more than ordinary interest to some readers.

DRAWING.

Fig. 34 is a plan and sections of a screw and wheel, showing the two forms of teeth in general use, viz., the straight and concave, as shown at *F* and *G*. In the small drawing here shown, the curves of the faces of the thread of the screw are portions of a cycloid generated by the circle *A*, the diameter of which is half that of the pitch circle of the wheel, rolling on the pitch line *BC;* and the curves of the faces of the teeth of the wheel are portions of the involute of the pitch circle.

But in making a large drawing, or one for practical purposes, the odontograph is a better form of tooth, as



Figs. 34, 35, and 36.

it is wider at the flank, and consequently stronger, and it is also better for moulding, as it draws from the sand much easier.

The manner of projecting the helix of the centre of the face of the tooth is shown at Fig. 37. The semicircle represents the diameter of the body of the screw, or worm. Divide this into any number of equal parts, as 1, 2, 3, 4, etc.; from *H*, set off half the length of the pitch of the screw, and divide it into a number of parts corresponding with those into which the circle has been divided, viz., 1, 2, 3, 4, etc. From each of these points raise perpendiculars, and from the points correspondingly figured in the circle draw horizontals; those intersecting will give the points through which the helix, forming the centre of the face of the concave tooth, may be traced.

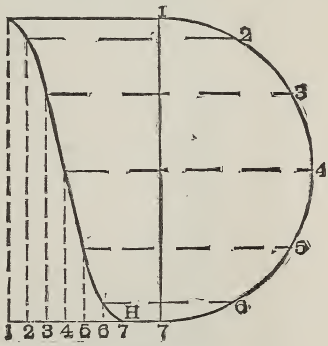


Fig. 37.

Now, by referring to Fig. 35, it will be seen that the pitch diameter at the end of the concave tooth is larger than it is at the centre of the tooth, and consequently travels farther when revolving. For this reason, the end of the tooth should be made as much narrower than the centre of the tooth as the difference in the distance of the travel may be, from where the tooth first comes in contact with the screw, until it leaves the same, as shown by the arrow *EE*, Figs. 34 and 36.

The angle of the tooth is as the pitch of the screw to the pitch circle of the same. Example: pitch of screw, 2″; circumference of pitch circle, $12\frac{1}{2}$″; angle of tooth, 2″ in $12\frac{1}{2}$″. (See Fig. 35.)

The pattern should be made to part through the centre of the teeth and rim, at *J J*, Fig. 34. The

hubs should be loose, as they will draw from the sand easier.

MOULDING.

When moulding, use a two-part flask, bed the pattern in the floor, and make the parting at points of teeth *K*, Fig. 38. Set on body of flask *L*, Fig. 39, fill in and

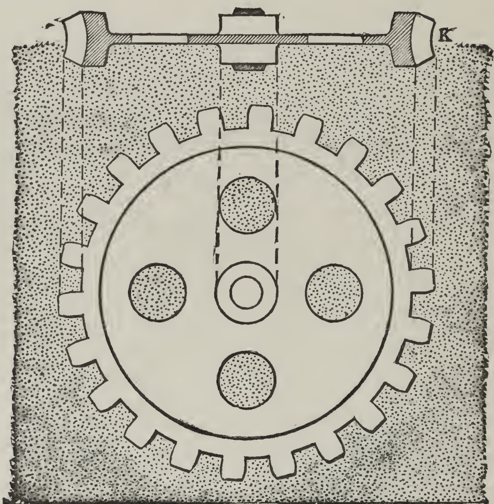
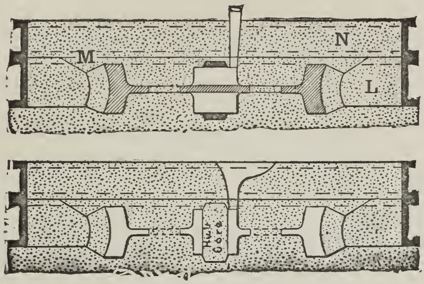


Fig. 38.

mould outside of the rim and between the teeth, and make the parting at points of the same, as shown at *M*, Fig. 39. Now put on cope *N*, ram it up, and make the gate. Then lift off the cope, and draw the upper half of the pattern. While doing this the pattern must be turned to the right or left, as required, in exact ratio to the angle of the teeth. Lift the body-flask *L*, turn it over, and draw the remaining parts of the pattern. Set hub core, finish the mould, close it up, and you are ready to cast, as shown in Fig. 40.

There are other ways of making these gears: some use a two-part flask, and draw the pattern to the centre, while others prefer coring the teeth.



Figs. 39 and 40.

I might add that the above method also holds good in making angle-toothed gear.

CHAPTER VIII.

MOULDING LARGE SHEAVE-WHEELS, AND FORMING THE RIM WITH SWEEPS.

MANY pattern-makers and quite a number of moulders have worked for years at their trades, and have never seen a sheave-wheel made without a complete pattern, and would not know how to make one if called

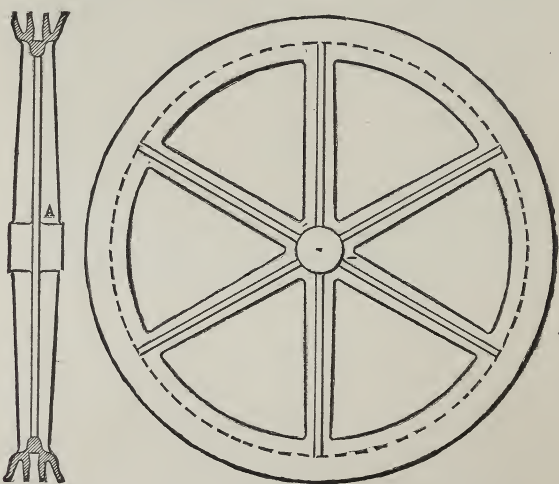


Fig. 41.

upon to do so. Although large sheaves are frequently used, we rarely require more than one or two alike; and, as the rim of such a wheel is an expensive pattern to make, it very seldom pays to do so.

For this reason I have concluded to illustrate the following method, by which wheels having any number of grooves can be made with but little expense for patterns, and scarcely any extra work while moulding: —

Fig. 41 is the plan and elevation of a sheave-wheel with three grooves. For such a wheel, make a complete

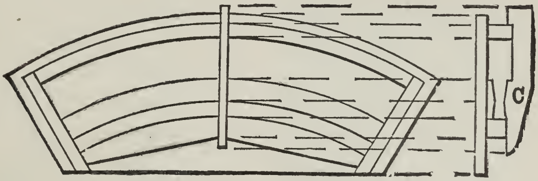


Fig. 42.

pattern of hub and arms. The hub and ribs *A*, on the side of the pattern, must be loose; and the ends of the ribs on both sides should be cut to the shape of the outside of the rim, as shown at *B*, Fig. 43.

Fig. 42 is a core box for the centre groove. It is a plain box, open on the top, and a strickle-piece, *C*, used for scraping off the same.

MOULDING.

When moulding, bed the pattern in the floor deep enough to have sand for forming the top of the rim or bottom of copes, and then ram it up around the outside at *D*, Fig. 43, and level with the top edge of the arm. We now take the strickle-board *E*, and bolt it to the arm of the spindle, as shown at *F*, Fig. 43. With this scrape off the sand level with the top edge of the arms, and also form the outside of the rim of the wheel. Having done this, we put on the loose ribs and hub *A;* set the cope flask, and ram it up, as shown at *G*, Fig.

43; lift it off again, and draw the loose ribs *A*. When this is done, take strickle-board *H*, Fig. 44 (on which

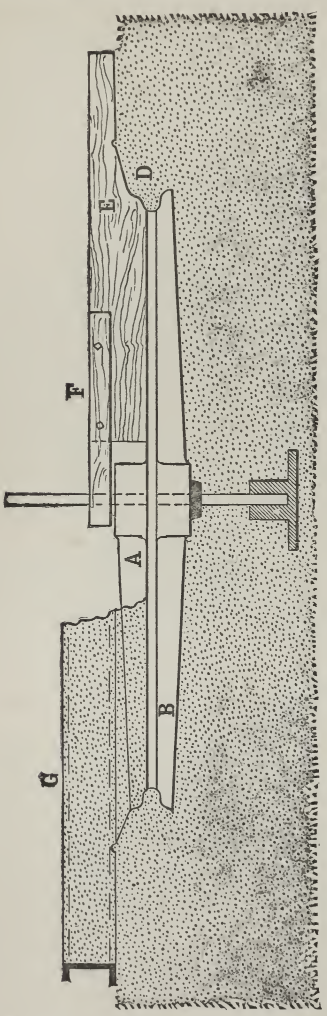


Fig. 43.

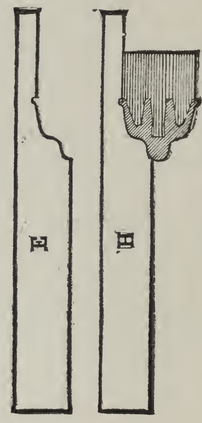


Fig. 44.

has been drawn a full-sized sketch of the rim of the wheel and the core print required, as shown at *J*), and

bolt it to the arm of the spindle at *K*. With this we scrape away the sand *D*, Fig. 43, and form the bottom

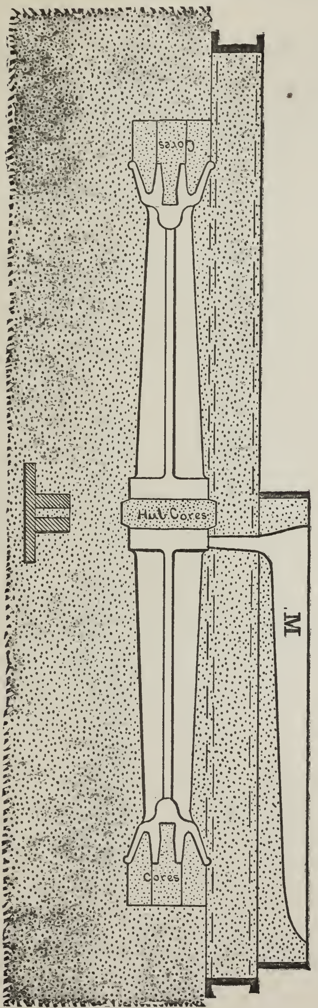


Fig. 46.

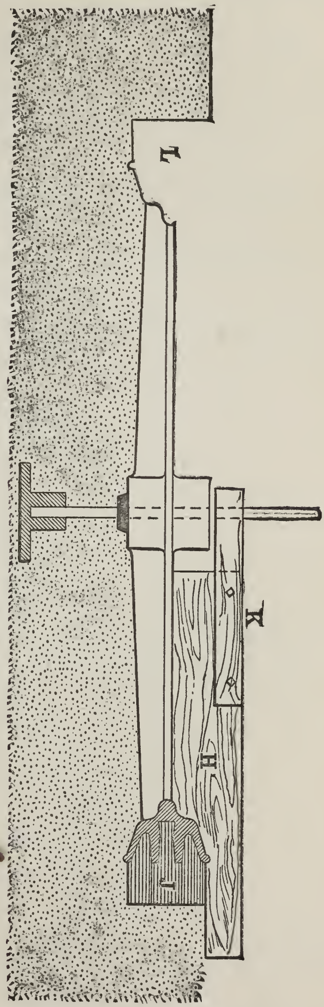


Fig. 45.

of the mould for the rim of the wheel, and also the core print, as shown at *L*, Fig. 45.

We are now ready to take off the strickle-board and spindle, draw from the sand the pattern of the arms, and finish the mould.

Having done this, set the rim and hub cores, close the mould, make runner-gate *M*, set on the weights, and we are ready to cast the wheel, as shown at Fig. 46.

CHAPTER IX.

MOULDING FLY-WHEELS WITHOUT A FULL PATTERN.

Fig. 47 is a section and elevation of a fly-wheel 8′ 6″ diameter by 8″ face, with hub 11″ long.

Now, it frequently happens that the casting for such a wheel is wanted in a very short time (say two or

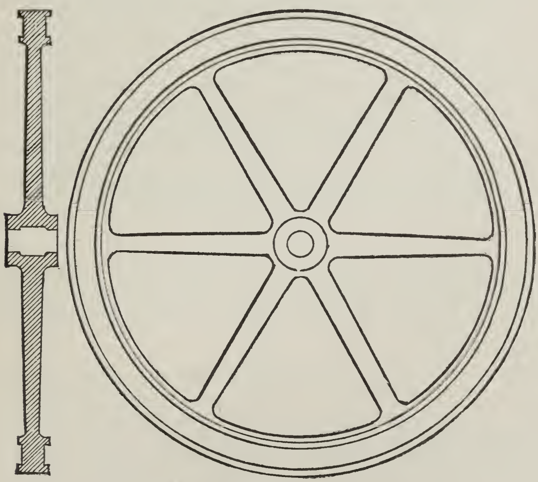


Fig. 47.

three days), and in that case the following method of making it is a good one.

We make a segment of the rim of the wheel, as shown at Fig. 48. The strips for the panel in the rim

of the wheel should be loose on one side of the segment, as they are wanted when finishing the mould.

We now make the arm core box, shown at Fig. 49. This box has a section of the hub, the bead on the in-

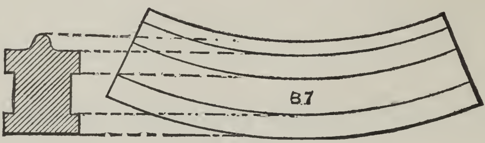


Fig. 48.

side of the rim of the wheel, and also half the arm of the wheel, set in the ends and bottom, as shown at *E* and *F*. The depth of the box should be just equal to

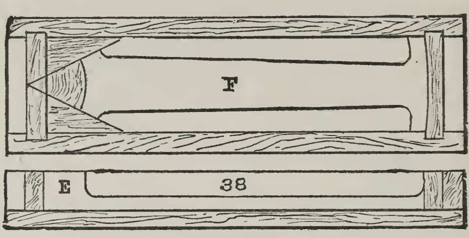


Fig. 49.

half the width of the face of the rim. In the present example, the face of the wheel is 8″; the depth of the box must be 4″.

When the hub of the wheel is longer than the width of the face of the rim, we make a pair of plain disks or washers, one of which—with hub core print attached—is shown at Fig. 50.

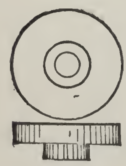


Fig. 50.

These disks or washers must be the exact diameter of the hub of the wheel, and the thickness of the difference between the depth of the arm core box and half the length of the hub. Ex-

ample: half the length of the hub, $5\frac{1}{2}''$; depth of core box, $4''$; thickness of washer, $1\frac{1}{2}''$.

Both these washers and hub core prints must have a hole through the centre, about one-sixteenth larger than the diameter of the spindle used in the foundry.

G, Fig. 51, is a plain strickle-board, with the projec-

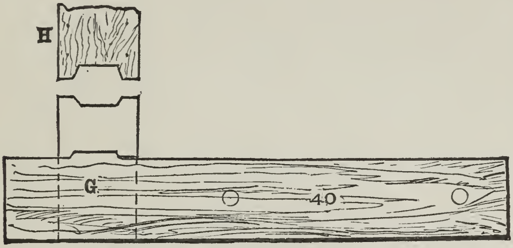


Fig. 51.

tions on the bottom edge made to fit the panel on the side of the segment of the rim; and *H* is a piece made to screw to *G*, as shown by dotted lines. The bottom end is cut out in the form of the panel mentioned above.

MOULDING.

When moulding, make an excavation in the floor the

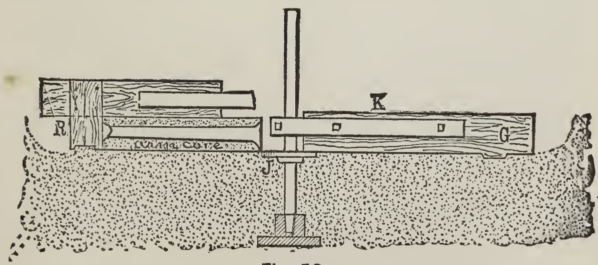


Fig. 52.

depth of the face of the wheel; set the step and spindle; then take one of the washers and hub core print, Fig. 50, and bed it in, as shown at *J*, Fig. 52.

We now take the strickle-board *G*, and bolt it to the arm of the spindle, as shown at *K*. With this scrape off and bevel the bottom of the mould. We are now

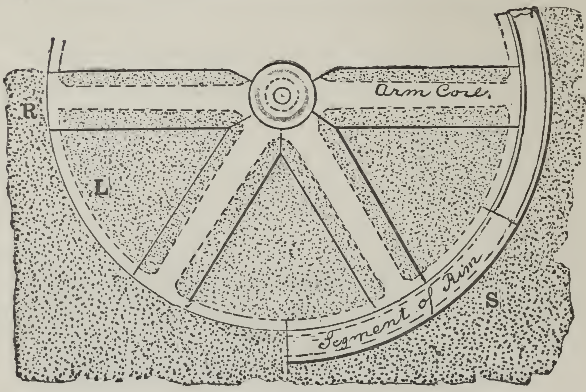


Fig. 53.

ready to set the arm cores, fill in between the arms and around the outside, as shown at *L*, Fig. 53. Having done so, take the strickle-board *G*, and scrape off the

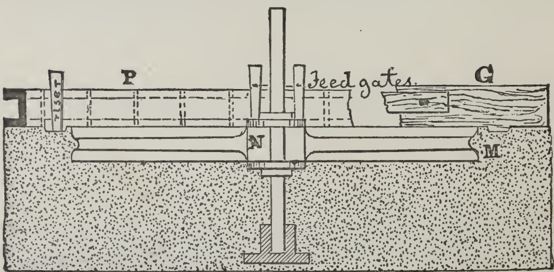


Fig. 54.

top of the mould, and form the panel in the rim of the wheel, as seen at *M*, Fig. 54.

The hub washer and core print are now set, as shown at *N*, and the cope flask *P* put on, rammed up, lifted off again, and finished.

Now make the strickle-piece *H* fast to *G*, and with it scrape out the sand around the outside of the arm cores, as shown at *R*, Figs. 52 and 53.

We can now take the segment of rim, set it in position, and ram up the outside, as seen at *S*, Fig. 53.

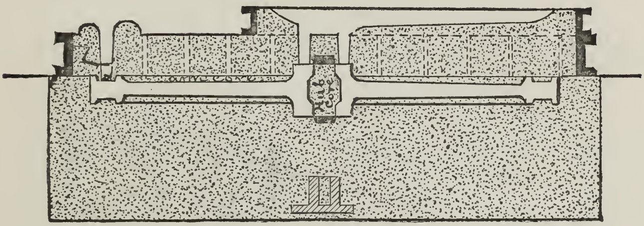


Fig. 55.

We are now ready to take up the spindle, draw the hub washers and print, finish the mould, close it down, make runners, risers, etc., as shown at Fig. 55.

CHAPTER X.

MOULDING HEAVY, WIDE-FACED BAND-WHEELS, WITH SWEEPS AND DRY-SAND CORES.

AMONG the many heavy castings required in the construction of general machinery, perhaps none are more frequently called for than band or balance wheels.

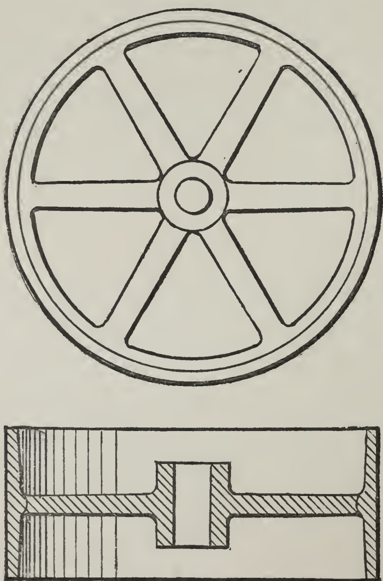


Fig. 56.

There are, of course, several good ways of making such wheels without a pattern, and the plan shown herewith

(although not perhaps new) I think is yet one of the best.

Suppose we need a wheel 8′ in diameter, 2′ face, with six arms, as in Fig. 56. We first make a segment of the

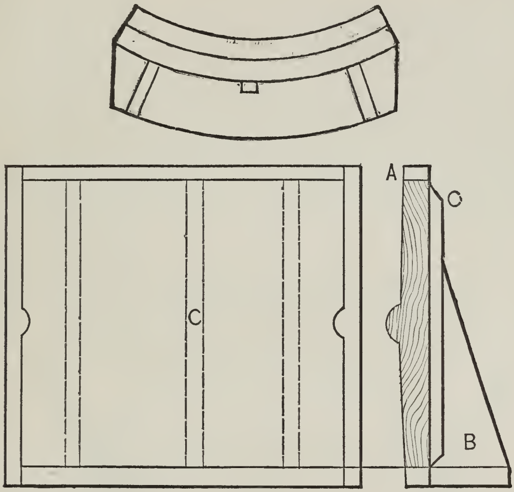


Fig. 57.

rim, as shown in Fig. 57. This segment may be made any convenient length, say from 2′ to 2′ 6″ long. On each edge of this segment we put a print the full length and width, and about 2″ thick; also a bottom or steady piece, and two braces, as shown at *B*. If the face of the wheel is rounding, we screw parallel piece *C* on the centre. This is to be used for plumbing the face of the segment when moulding the wheel (Fig. 60).

Fig. 58 shows the box for making sectional cores for the face and edges of the rim of the wheel, as shown at *D*, Fig. 61. It is a plain box, open at the top and bottom. The cut also shows a strickle-board *E*, which is used for scraping off the face of the core.

Fig. 59 is the plan and section of the arm core box.

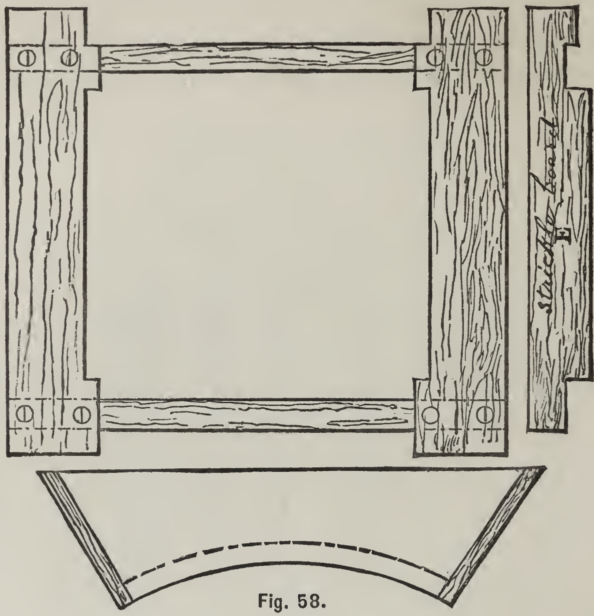


Fig. 58.

It should be made half the depth of the full length of

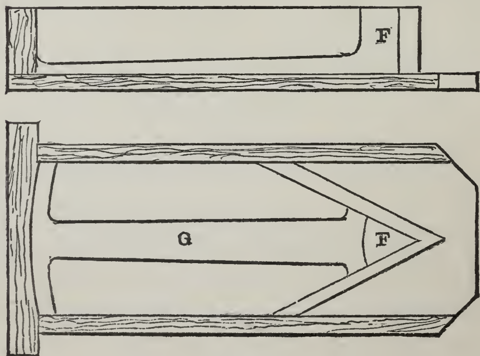


Fig. 59.

the hub of the wheel. For instance: if the hub of the

wheel is 13″ long, the box should be 6½″ deep. A section of the hub and half the arm is set in the "hub end" and bottom of the box, as shown at *F* and *G*.

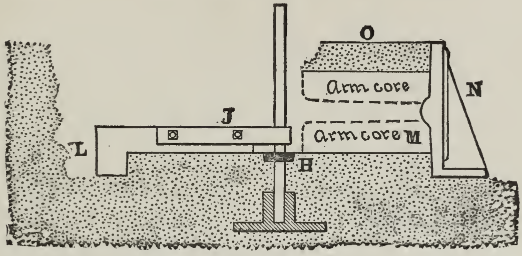


Fig. 60.

MOULDING.

Having made the proper excavation in the floor, we

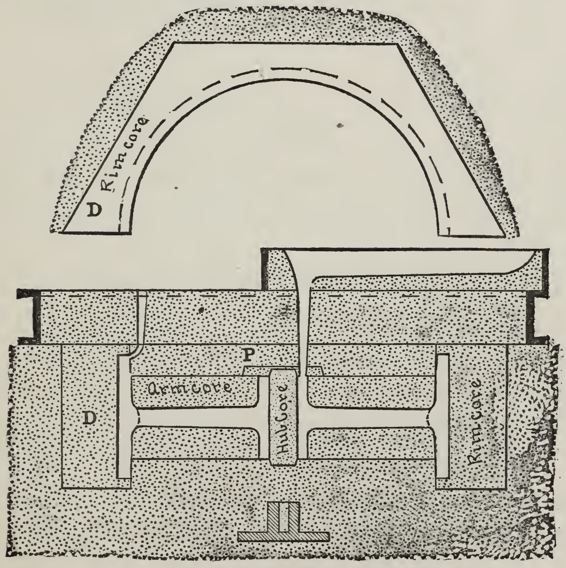


Fig. 61.

prepare the bed or the mould, and set the spindle and

hub core print *H*, Fig. 60; we then take the sweep-board *I*, Fig. 62, and bolt it to the arm of the spindle, as shown at *J*, Fig. 60.

The projection *K* on the sweep-board must be the length of half the width of the face of the wheel and the print *A* or bottom board included, less the depth of the arm core box. Example: half the width of the face of the wheel, 12″; thickness of print, 2″; $12'' + 2'' = 14''$; depth of arm core box, $6\frac{1}{2}''$; $14'' - 6\frac{1}{2}'' = 7\frac{1}{2}''$, as shown at *K*, Fig. 62.

Having bolted the sweep to the spindle-arm, as stated

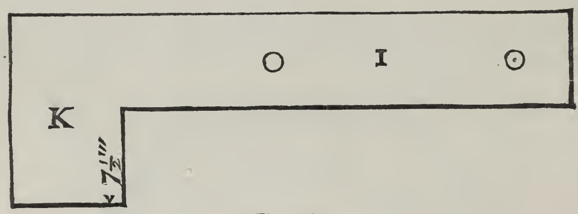


Fig. 62.

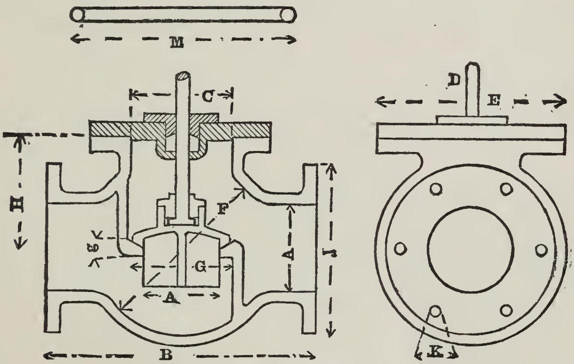
above, we sweep out the sand, as shown at *L*, Fig. 60, and form the bottom for segment of rim and rim core *D*, Fig. 61.

We now take off the sweep, and set all the arm cores, as shown above. When this is done, take the segment of rim, set it in position as shown at *N*, and mould up level with the top of the print, as shown at *O*, moving it around from place to place until the circle is completed. We now set the rim cores *D*, fill in the sand, and ram up the outside, set the hub core and cover it with cake core, as shown at *P*. Set on cope flask, ram it up, making feed-gates, risers, etc., as shown at Fig. 61.

CHAPTER XI.

GLOBE-VALVES.

FIGS. 63 and 64 represent a side section and end elevation of a common globe-valve; and as globe-valves are an important detail in pattern-shop and foundry practice, they will afford a good subject for this article.



Figs. 63 and 64.

The following tables give the principal dimensions of globe-valves, from $\frac{1}{4}''$ to $5\frac{1}{2}''$ inclusive:—

TABLE OF DIMENSIONS OF GLOBE-VALVES HAVING HEXAGONAL FLANGES:

From $\frac{1}{4}''$ to $2''$ inclusive.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*M*
$\frac{1}{4}''$	$\frac{7}{16}''$	$1\frac{5}{8}''$	$\frac{7}{16}''$	$\frac{5}{16}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$\frac{5}{8}''$	$\frac{5}{8}''$	$\frac{1}{4}''$	$\frac{13}{16}''$	$1\frac{5}{8}''$
$\frac{3}{8}''$	$\frac{9}{16}''$	$1\frac{7}{8}''$	$\frac{9}{16}''$	$\frac{5}{16}''$	$\frac{7}{8}''$	$1''$	$\frac{3}{4}''$	$\frac{3}{4}''$	$\frac{1}{4}''$	$\frac{15}{16}''$	$1\frac{5}{8}''$
$\frac{1}{2}''$	$\frac{3}{4}''$	$2\frac{1}{4}''$	$\frac{3}{4}''$	$\frac{3}{8}''$	$1''$	$1\frac{1}{4}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$\frac{1}{4}''$	$1\frac{3}{16}''$	$2''$
$\frac{3}{4}''$	$1''$	$2\frac{5}{8}''$	$1''$	$\frac{3}{8}''$	$1\frac{3}{8}''$	$1\frac{1}{2}''$	$1''$	$1\frac{1}{8}''$	$\frac{1}{4}''$	$1\frac{1}{2}''$	$2\frac{1}{4}''$
$1''$	$1\frac{1}{4}''$	$3\frac{3}{8}''$	$1\frac{1}{4}''$	$\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$1\frac{1}{4}''$	$1\frac{1}{4}''$	$\frac{1}{4}''$	$1\frac{3}{4}''$	$2\frac{3}{4}''$
$1\frac{1}{4}''$	$1\frac{1}{2}''$	$3\frac{5}{8}''$	$1\frac{1}{2}''$	$\frac{1}{2}''$	$2''$	$2\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{1}{2}''$	$\frac{1}{4}''$	$2\frac{1}{16}''$	$3\frac{1}{4}''$
$1\frac{1}{2}''$	$1\frac{3}{4}''$	$4''$	$1\frac{3}{4}''$	$\frac{1}{2}''$	$2\frac{1}{8}''$	$2\frac{5}{8}''$	$1\frac{3}{4}''$	$1\frac{3}{4}''$	$\frac{1}{4}''$	$2\frac{3}{8}''$	$3\frac{3}{4}''$
$2''$	$2\frac{1}{4}''$	$4\frac{1}{2}''$	$2\frac{1}{4}''$	$\frac{5}{8}''$	$2\frac{5}{8}''$	$3\frac{1}{2}''$	$2\frac{1}{2}''$	$2\frac{3}{4}''$	$\frac{3}{8}''$	$3''$	$4\frac{1}{2}''$

TABLE OF DIMENSIONS OF GLOBE-VALVES HAVING ROUND FLANGES AND BOLT-HOLES:

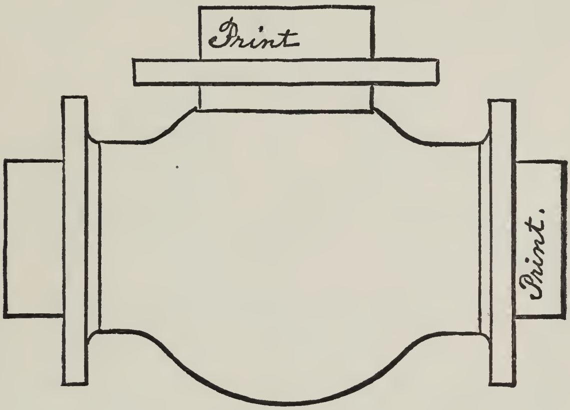
From $2\frac{1}{2}''$ to $5\frac{1}{2}''$ inclusive, advancing by half-inches.

A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*M*	*L* No. of Bolts.
$2\frac{1}{2}''$	$10''$	$3\frac{1}{4}''$	$\frac{7}{8}''$	$7''$	$6\frac{1}{2}''$	$3\frac{1}{8}''$	$4\frac{3}{4}''$	$\frac{7}{8}''$	$6\frac{3}{4}''$	$\frac{1}{2}''$	$7''$	4
$3''$	$11''$	$3\frac{3}{4}''$	$1''$	$7\frac{3}{4}''$	$7\frac{1}{4}''$	$3\frac{3}{8}''$	$5\frac{1}{4}''$	$\frac{7}{8}''$	$7\frac{1}{2}''$	$\frac{1}{2}''$	$8''$	4
$3\frac{1}{2}''$	$12''$	$4\frac{1}{2}''$	$1''$	$8\frac{3}{4}''$	$7\frac{3}{4}''$	$4''$	$5\frac{1}{2}''$	$1''$	$8\frac{1}{4}''$	$\frac{1}{2}''$	$8''$	5
$4''$	$13''$	$5\frac{1}{4}''$	$1\frac{1}{8}''$	$9\frac{3}{4}''$	$8\frac{3}{4}''$	$4\frac{1}{2}''$	$5\frac{3}{4}''$	$1''$	$9''$	$\frac{5}{8}''$	$10''$	5
$4\frac{1}{2}''$	$14''$	$5\frac{1}{2}''$	$1\frac{1}{8}''$	$10\frac{1}{4}''$	$9''$	$5''$	$6''$	$1''$	$9\frac{3}{4}''$	$\frac{5}{8}''$	$10''$	6
$5''$	$15''$	$6\frac{1}{4}''$	$1\frac{1}{4}''$	$11''$	$10\frac{1}{4}''$	$5\frac{1}{2}''$	$6\frac{5}{8}''$	$1\frac{1}{8}''$	$10\frac{1}{2}''$	$\frac{5}{8}''$	$12''$	6
$5\frac{1}{2}''$	$16''$	$6\frac{3}{4}''$	$1\frac{1}{4}''$	$11\frac{7}{8}''$	$11\frac{1}{8}''$	$6\frac{1}{4}''$	$6\frac{7}{8}''$	$1\frac{1}{8}''$	$11\frac{1}{4}''$	$\frac{5}{8}''$	$12''$	6

The figures in the first column denote the size of the valve; and those under *A*, *B*, *C*, *D*, *E*, etc., exhibit the proportional dimensions of the parts marked with corresponding letters on the drawing. Thus, for a $2\frac{1}{2}''$ valve, the total length over all is $10''$; diameter of valve-stem, $\frac{7}{8}''$; diameter of flange, $6\frac{3}{4}''$; diameter of bolts, $\frac{1}{2}''$; number of bolts, 4; diameter of hand-wheel, $7''$, etc.

Fig. 56 is a side elevation, while Fig. 66 may be called an auxiliary view, showing the pattern in the different stages of construction.

As the pattern must be parted through the centre, we first get out two pieces of wood, face them true on one side, peg them together with two dowel-pins, and hold them in place with a stout screw. This screw should



Fig, 65.

be set so that, when the pattern is finished, it will be about the centre of the globe or body of the pattern, as shown at *B*, Fig. 66.

The blocks, when thus prepared, must of course be large enough in diameter to allow for turning the globe, or body of the pattern; also long enough to make the neck and prints, with a liberal allowance for cutting off at each end.

In making small sizes of valves, we may say, up to $3\frac{1}{2}''$, that it is generally well to have the block long enough to make the branch: by so doing we can turn both the body of the pattern and the branch, while the

piece is in the lathe, and thus save the time that would be occupied in preparing the wood for the branch and chucking it in the lathe, if these parts were turned separately.

On very small valves, — in fact, all the sizes given in the first table, — the flanges are generally hexagonal in shape, and may be cut out of the solid; but, for the larger sizes, it is better to put them on in separate pieces, as shown at *C*, Fig. 66.

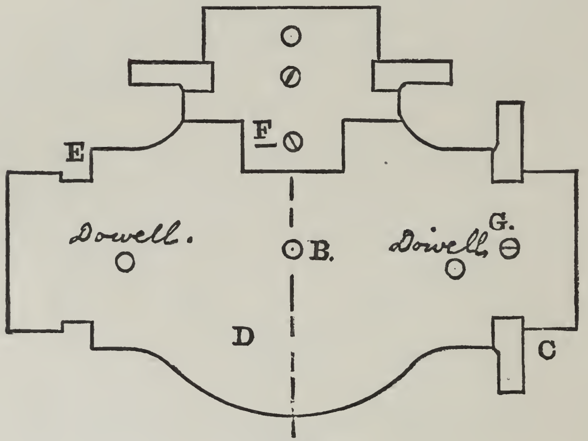


Fig. 66.

Having prepared the wood as directed above, it may be put in the lathe, and rough-turned down to within about ¼″ of the finished diameter. We then make a centre line around the body of the globe, as shown by dotted line *D*, Fig. 66; and then at the proper distance from this centre line, on each side, cut in the checks for receiving the flanges, as shown at *E*.

The piece intended for the branch should in like manner be checked in for the flange, and also have a tenon turned on the bottom end as shown at *F*, Fig. 66.

At this stage of the proceedings, the pattern is taken out of the lathe, and the screw which holds the pieces together may be removed, and the halves taken apart. The flanges may now be fitted in place, and held firmly with one or more screws, as shown at *G*. When this has been done, the halves of the pattern may be put together again, and secured in place with screws as before. It is then put in the lathe, and turned to the finished size.

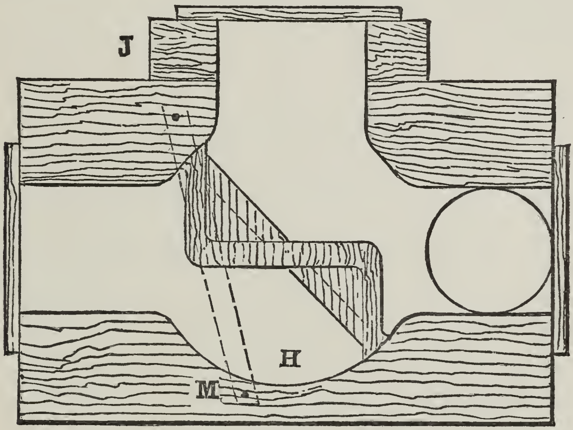


Fig. 67.

We now take out the pattern from the lathe, and at right angles with the parting; parallel with the centre line of the body, we cut off the side of the sphere and also work out the recess to receive the tenon *F*, and in that manner put on the branch, as shown in the figure.

At Fig. 67 we have shown a plan of the core-box required when the partition and valve-seat *G*, Fig. 1, follows with an equal thickness of metal around the circle of the valve-seat opening.

To make this box, we first get a piece of wood about one-half inch longer than the pattern including the prints, and of sufficient width and thickness to allow us to work out the sphere, and still have about one inch of thickness left on the bottom and sides of the same, as shown at *H*.

We then mount the block upon a face-plate, and turn out the centre. When this has been done, we may take it out of the lathe, and cut it off to the right length; taking care to have the centre of the sphere an equal distance from each end, so that, by reversing the position of the partitions and valve-seat, both halves of the core can be made from one box.

If the block is not wide enough to make the opening for the branch, we shall then have to put on the extension piece, shown at *J*. We then lay off the openings for the neck and branch, and cut them out by hand.

In order to be able to reverse the position of the partitions, we must have two pairs, or four pieces; each piece being one-quarter of a circle. They may be turned out of two different pieces, and afterwards cut apart, and, when fitted in position, held so with a strip of wood made fast to the top edge and screwed to the face of the box, as indicated by the dotted lines and screw-heads shown at *M*.

When the core has been made, and is ready to take out of the box, we remove the screws, and draw each piece separately, and then turn the core over, and lift off the body of the box. Each half is thus made separately, and pasted together when dry.

For small sizes of valves, or when there is a great number to be made from the same pattern, these partitions should be made of brass, as they will then keep

their shape, and can be drawn from the sand more easily.

MOULDING.

Globe-valves may be cast in almost any position,—either vertically or horizontally,—and some moulders even prefer to set them on an angle.

A very good method of casting large sizes is shown at Figs. 68 and 69, and is as follows:—

First take one half of the pattern, and lay it—face down—on a turn-over board. Then set in proper posi-

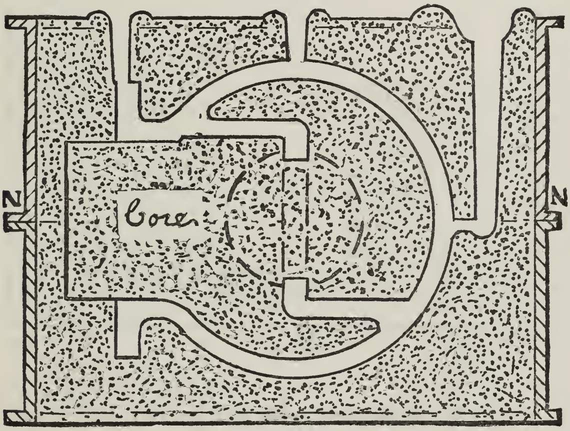


Fig. 68.

tion the bottom section of the flask, shown in Fig. 68, fill it in, and mould it level with the top; turn it over, and make the parting at *N.* Then set the other half of the pattern in place, put on the cope flask, set the feed-gate and riser-pins, fill it in, and ram it up in the ordinary manner of doing such work. We now lift the cope off, and draw the pattern, then finish the

mould, cut the runners *R*, and set the core as shown in Fig. 69. When this has been done, and the cope set

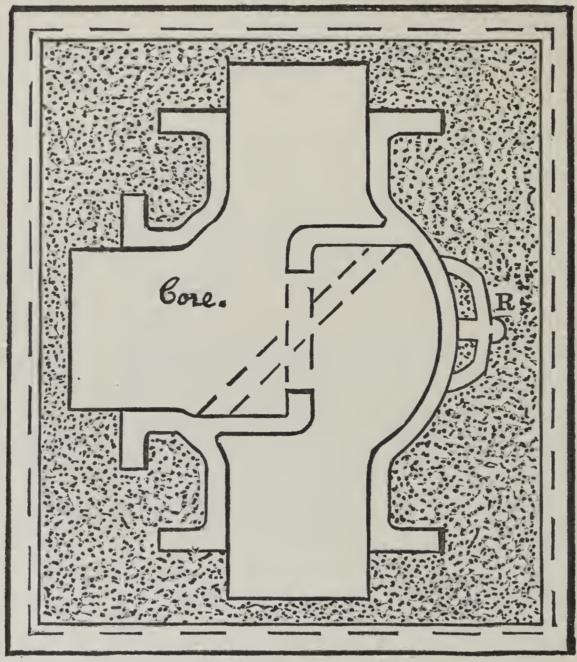


Fig. 69.

in place and made secure and tight, the mould is ready to receive the metal.

CHAPTER XII.

CYLINDER WORK.

There is no other mechanical term in the dictionary so comprehensive, nor one which covers such a great variety of forms, as the word "cylinder." And — comparatively speaking — there are no other castings required for the construction of general machinery in which the quality is of more importance than in cylinder castings.

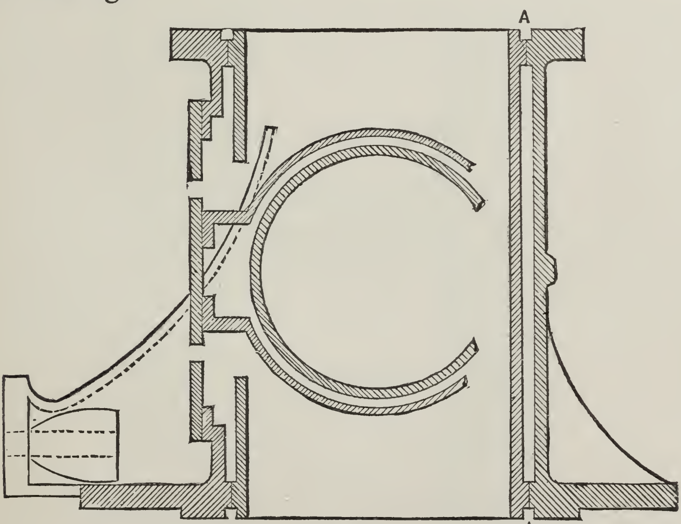


Fig. 70.

Figs. 70 and 71 are a section and an end elevation of an air-cylinder for a large compressor; and in that case it is necessary for the casting to be — practically speaking — perfect, as it has to stand an hydraulic test of a very high pressure.

As will be seen by the drawing, the cylinder is made in two sections; the inside or liner — which is surrounded by a water-jacket — being a separate casting turned and fitted to the body, the joints being made at the belts *A*.

The outside, or body of the cylinder, has an opening

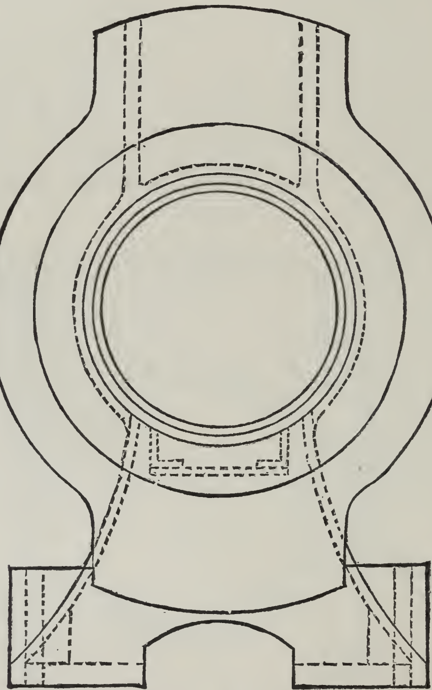


Fig. 71.

for a sediment door cast in the bottom, which is afterward covered with a plate, as shown at Fig. 70.

The pattern for the inside or liner is shown at Fig. 72. It has two draw-irons on the top end, as shown at *E;* and the bottom flange and *K* print are made loose at the dotted line *F*.

Fig. 73 is a side elevation of the pattern for the body of the cylinders. The flanges, ribs, and feet are loose, as shown at dotted lines; and the facing for sediment door and the boss on the top of the cylinder are also loose, and held in position with the dowels, as shown in the figure.

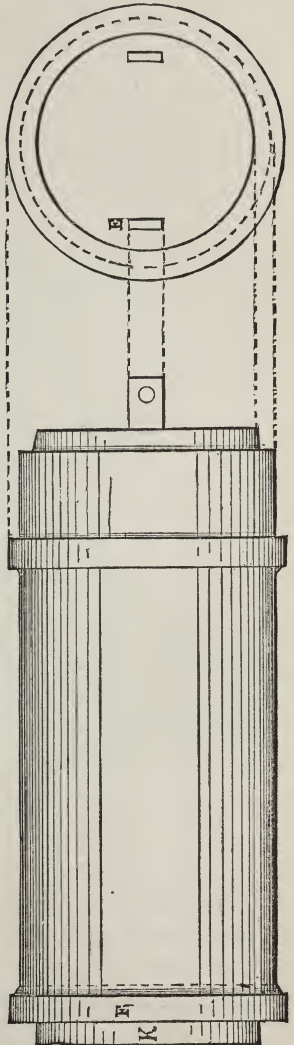


Fig. 72.

A plan and section of the core-box for the sediment door opening is shown at Fig. 75. It is an open box, parted through the centre, and the top made concave to fit the body core of the cylinder.

MOULDING.

The plan of casting the inside or liner section of the cylinder is shown at Fig. 74. The bottom flange of the pattern and the print *K* are first set in the flask *L*, and rammed level with the top, where the parting must be made. The body flask *M* is then put on, and the pattern set in place, moulded level with the top edge of the flange, and parted at *N*. We are then ready to set on the cope *P*, ram it up, and set feed-gates and riser-pins, lift it off again, and draw the body of the pat-

tern; while the bottom flange and print will, of course, remain in the mould until the body flask *M* is lifted off, when it can easily be drawn from the sand.

We are now ready to finish the mould. Set the body core, put the flask *M* back in place again, close down the cope, and make feed-gates and risers as shown.

When moulding the body of the cylinder, first set

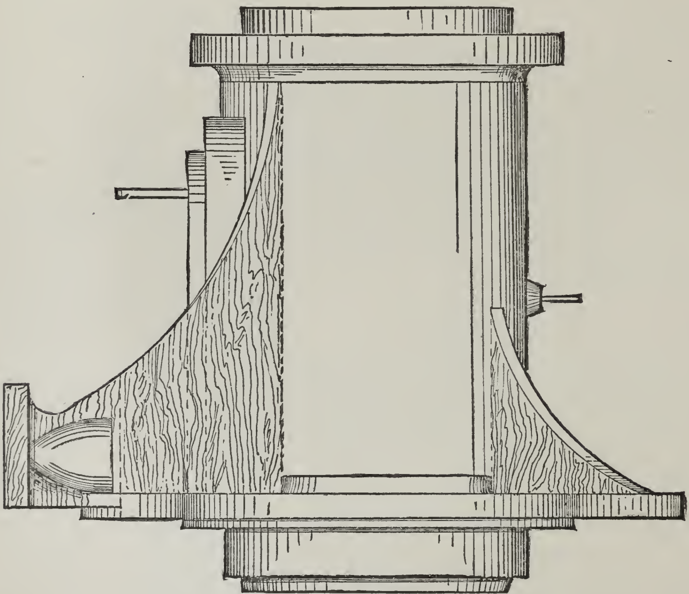


Fig. 73.

the pattern in the position shown at Fig. 76. By setting it thus, we have a chance to fill in and ram between the ribs and feet *G* and *H*. When the section of the body flask *R* is set, as shown in the figure, we can then fill in and mould up to about the centre of the pattern. The section of flask *S* is then set in place, and moulded up to *T*, where the parting must be made. We are then ready

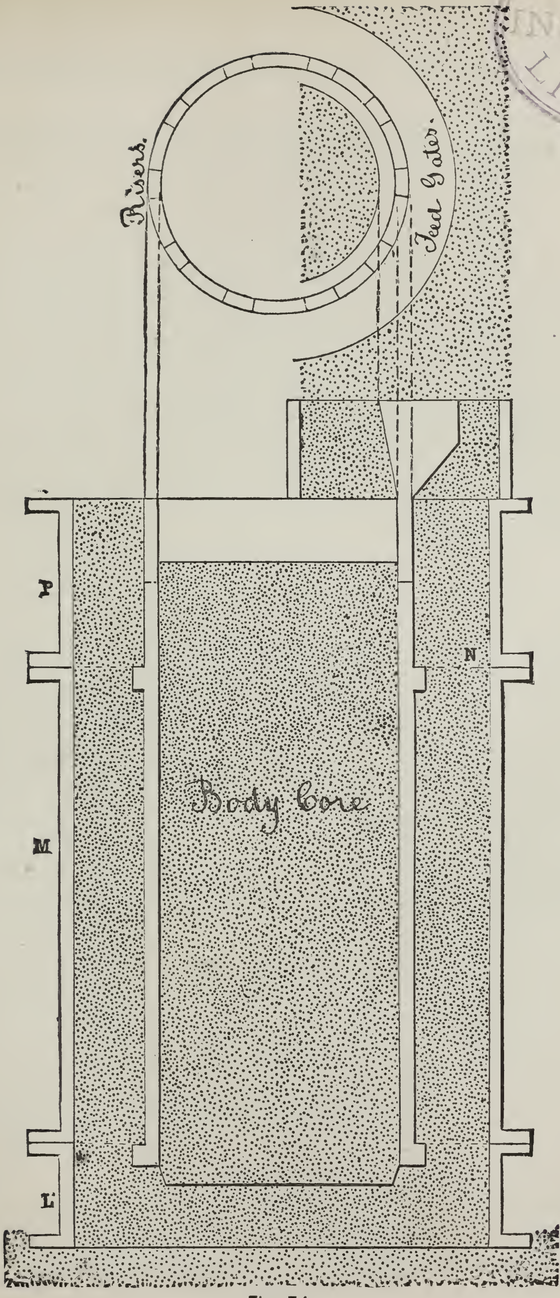


Fig. 74.

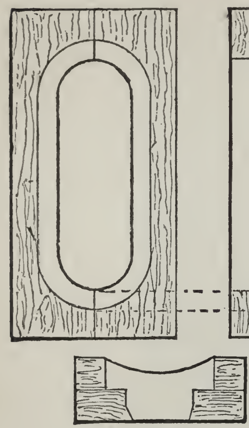


Fig. 75.

to set the top section of the flask, fill it in, and ram it up, as shown in the engraving. The mould must then be turned over, and the cope flask *W*, Fig. 77, put on, filled in, rammed up, and lifted off again. The pattern can then be drawn from the sand as follows: —

First draw the top flange, and then the body of the cylinder; the ribs, feet, bottom flange, and other loose pieces remaining in the mould. We, may now lift off the body flask,

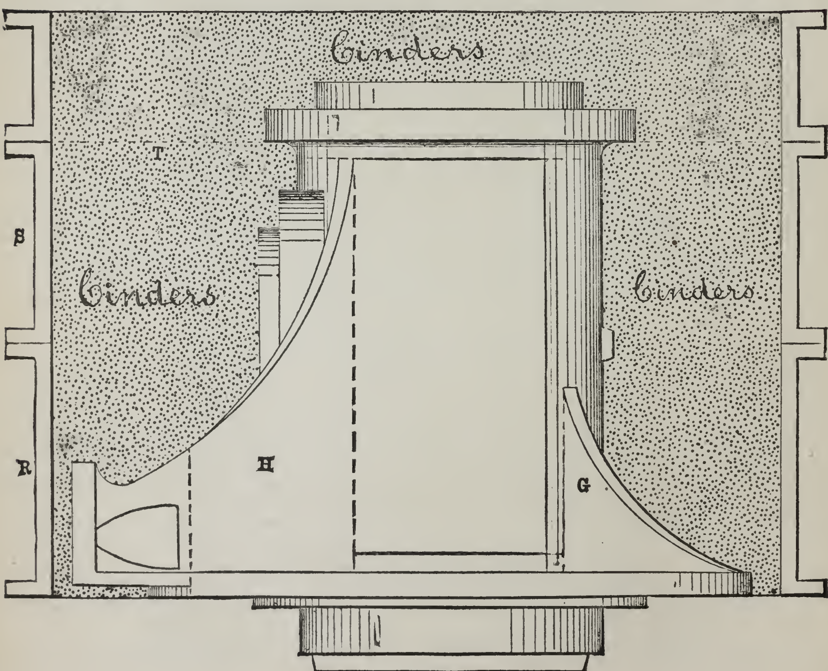


Fig. 76.

and set it in the most convenient position to draw the different sections of the pattern still remaining in the sand.

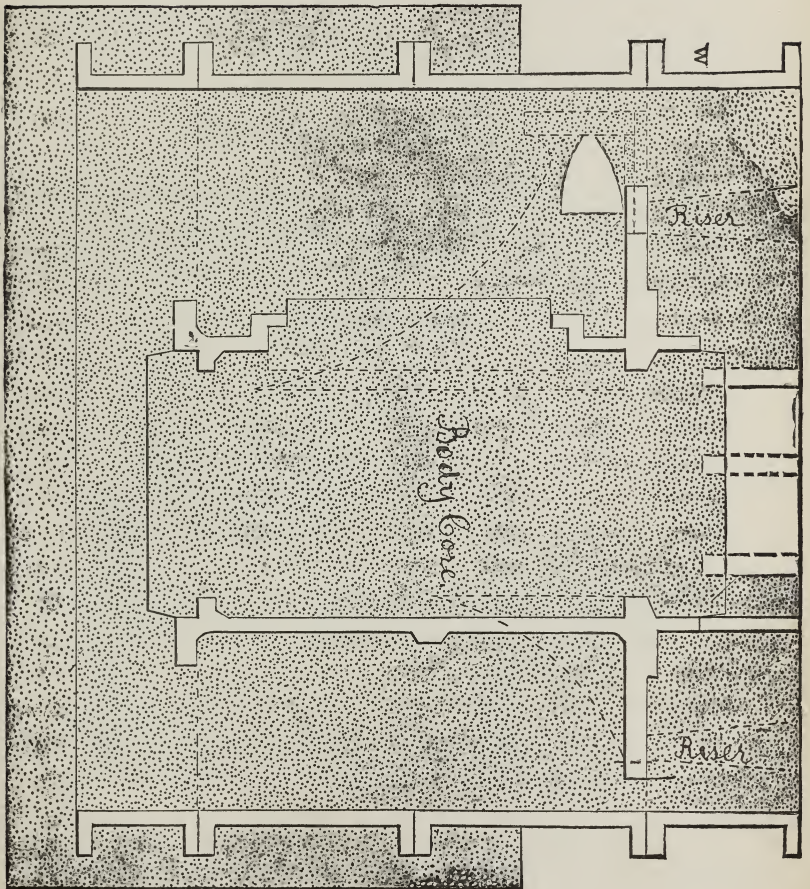


Fig. 77.

When the mould is finished, and the cores set, it is all closed up, as shown at Fig. 77, and the feed-gates and risers made much the same as those shown at Fig. 74.

CHAPTER XIII.

THE LOCOMOTIVE CYLINDER.

FIG. 78 is a horizontal section of a locomotive cylinder, showing the steam-inlet, port, exhaust, and other details. Fig. 79 is an end elevation, with the cylinder-

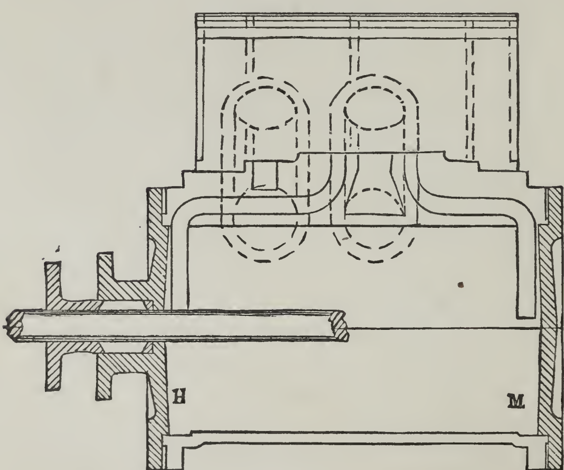


Fig. 78.

head removed. The figure also shows part of the saddle flange, which extends across the engine, and is bolted to the smoke-box; while a section of the main frame, to which the side flange of the cylinder is bolted, is shown at *A*. The steam-inlet, exhaust, and steam-ports are clearly shown in both the figures. The exhaust is, of

course, to be made of larger dimensions, so as to carry away the greater volume of expended steam after it has driven the piston; and, as shown in the end view, the steam-ports extend through nearly a third of the circumference of the cylinder.

The front and back covers are shown at *H M*, Fig. 78,

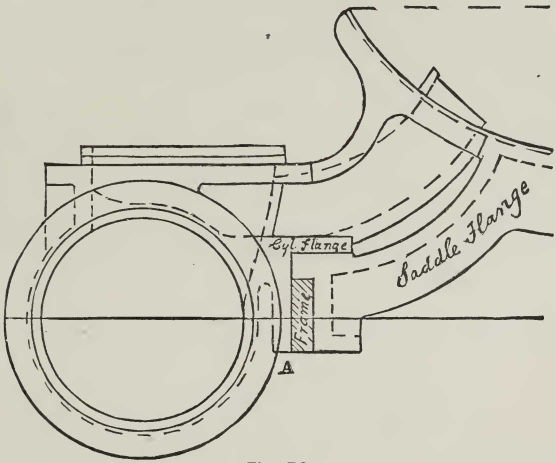


Fig. 79.

and are slightly concave, in order to conform to the shape of the piston, and reduce the clearance.

PATTERN MAKING.

Figs. 80, 81, and 82 are three views of the pattern, and Fig. 83 represents the core-box for the extension or saddle of the cylinder. The pieces *L T*, which must be made of the size and form of the outside of the wall of metal required around the steam-inlet and exhaust cores, should be made loose, and held in place with dowel-pins or screws. It is not necessary to give any illustrations of the other core-boxes required; as the pattern makers can see all the different shapes and

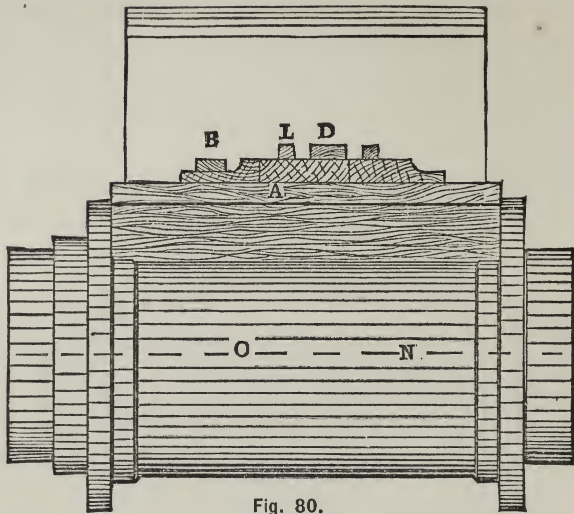


Fig. 80.

curves on the general drawing, Figs. 78 and 79, and can

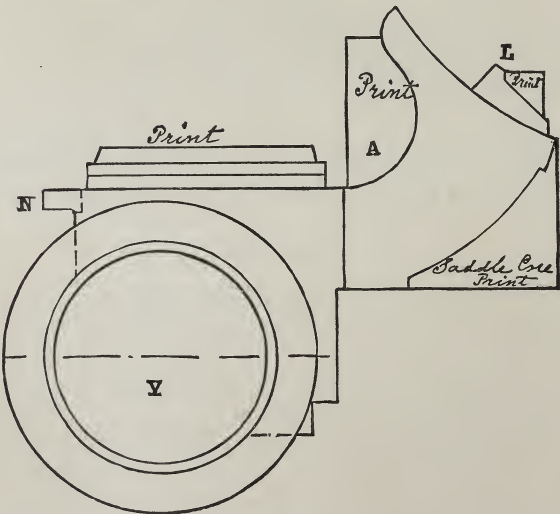


Fig. 81.

also see the cores set in the mould at Figs. 84 and 85,

so that each individual can use his own judgment with regard to the best way to make the boxes, and be guided in his operations by different circumstances and the facilities at hand, such as lumber, wood-working machinery, etc. Fig. 80 is a front elevation of the pattern of the cylinder. The prints for the steam-inlet, ports, and exhaust cores are shown at *B*, *L*, and *D*. The

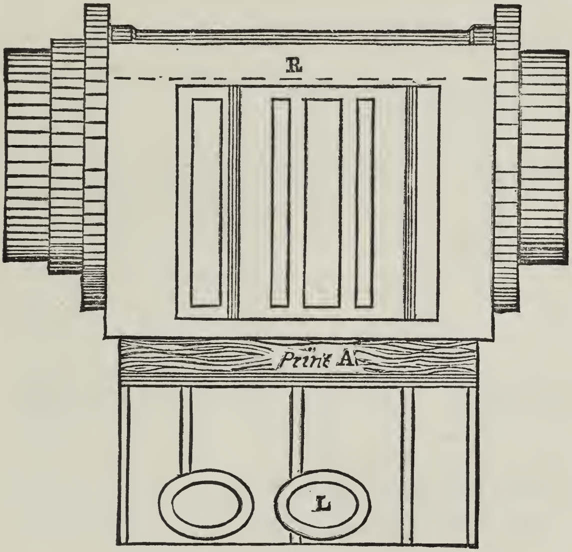


Fig. 82.

pattern is made to part through the centre of the body of the cylinder, as shown by the dotted line *O N*. The flange *A* is made loose at the dotted line *R*, Fig. 82, and sits in a rabbet, as shown at *N*, Fig. 81. Fig. 82 is a plan of the pattern showing the valve-seat and the bottom of the steam-chest, and also the chipping strips on the face of the saddle. Fig. 81 is an end elevation of the pattern, and the correspondence of the letters with those

of Fig. 82 will show the reader the different projections of the same parts; thus, *L* is the joint for the end of the exhaust core. Having given the above description of the pattern, and how to make it, we will leave the pattern-making for the present, and turn our attention to an important part of this subject; viz., —

MOULDING.

Fig. 84 is a sectional end view of the mould, showing the shape of the flask and all the cores when they are set in their proper positions.

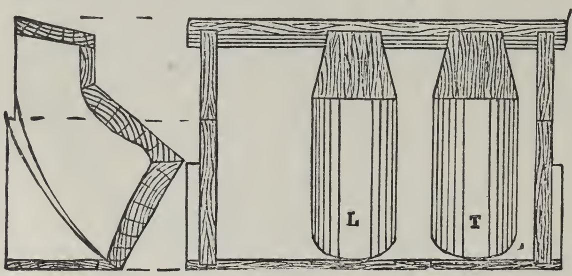


Fig. 83.

Fig. 85 is a plan of the mould with the cope lifted off, and the steam-inlet, exhaust, and steam-port cores set in place.

As will be seen by Fig. 84, the flask is made with a jog or step, corresponding in shape to an end view of the surface of the pattern, with the section *Y*, Fig. 81, lifted off.

When the large section of the pattern has been set in the position shown in Fig. 84, and the mould filled in and rammed up to *K*, the parting may be made level with the edge of the flask. The small section of the pattern is then set in place, and the cope flask put on;

the feed-gate and riser-pins set in the position shown in the figure, and the mould filled in and rammed level with the top of the flask. We now lift off the cope, draw the pattern, finish the mould, and put it in the oven to dry.

The manner of setting the cores is shown in Figs. 84 and 85, and is as follows: —

We first set the core marked *A*, Fig. 84, and then

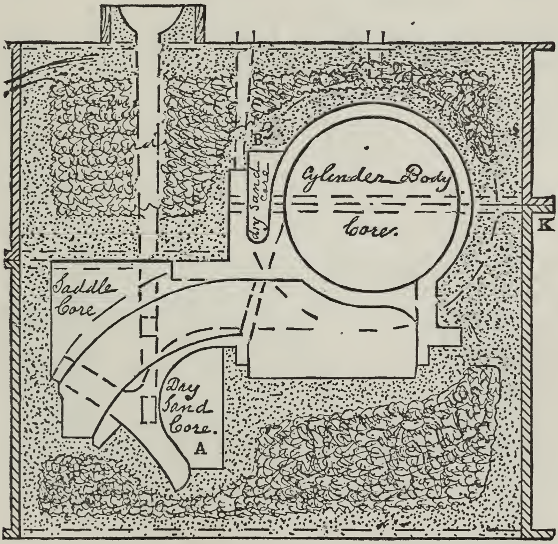


Fig. 84.

the steam-inlet and exhaust and port cores, as shown at Fig. 85. All these cores must be held in position by strong wires run down through the bottom, and made fast on the outside of the mould; and the outer ends of the port cores must be supported by chaplets.

The point of the saddle core shown at Fig. 84 is supported by chaplets set firmly upon the dry-sand

cores, marked *A*, in the same figure; and the large end is tied to the cope. The core for cutting out the metal between the side flange and the body of the cylinder is also tied to the cope, as shown at *B*.

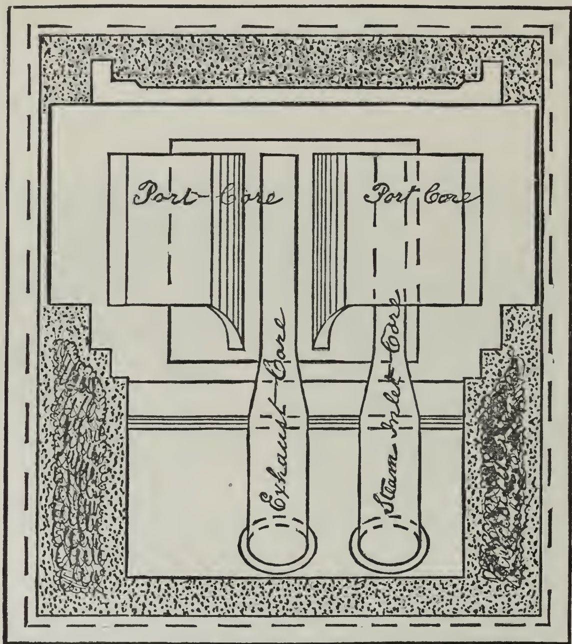


Fig. 85.

We may now set the cylinder body core, close the mould, and prepare to cast the cylinder.

CHAPTER XIV.

TWO WAYS OF MOULDING CYLINDERS.

AT Figs. 86, 87, and 88, we have shown a 14×24 cylinder with piston-valve, and the valve-chest cast on. One part of the drawing shows the plan, side and end sections of the cylinder casting; and another part represents the plan and side elevation of the pattern.

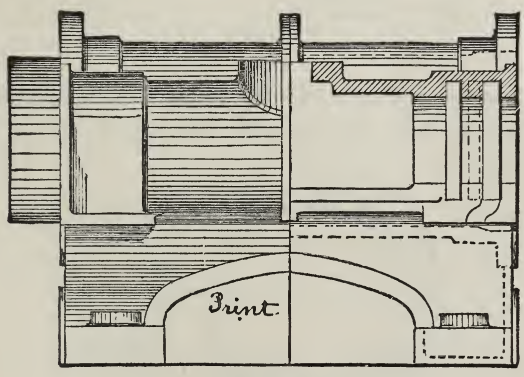


Fig. 86.

When the cylinder is to be cast horizontally, as shown at Fig. 92, the pattern should be parted through the centre of the body of the cylinder and valve-chest, and also through the upper part of the stand, where it joins the body of the cylinder. When it is to be moulded vertically, as shown at Fig. 93, the centre

belt and steam-inlet — in fact, all the bosses, etc. — must be loose.

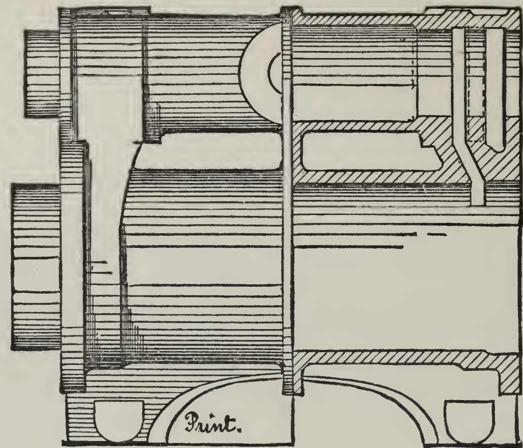


Fig. 87.

A plan and section of the valve-chest core-box are shown at Fig. 89. It is a half box; and it will be seen

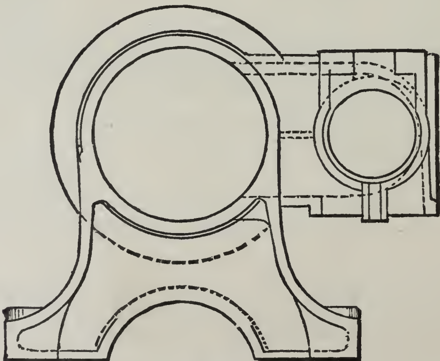


Fig. 88.

by the drawing that the body, port and exhaust cores are all made in one. The pieces of wood which form

the bottoms, divisions, and side of the port and exhaust cores, should be loose and an easy fit, so that they will come out of the body of the box with the core. They

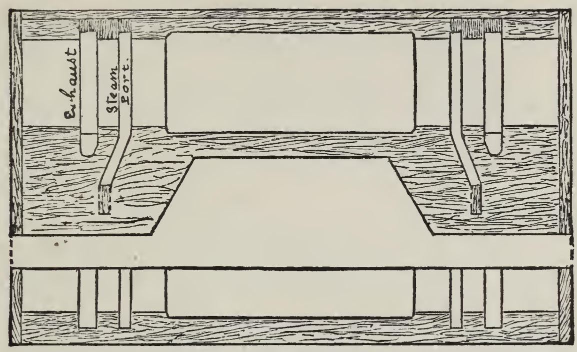


Fig. 89.

can then be easily drawn in sections, without breaking the port or exhaust cores.

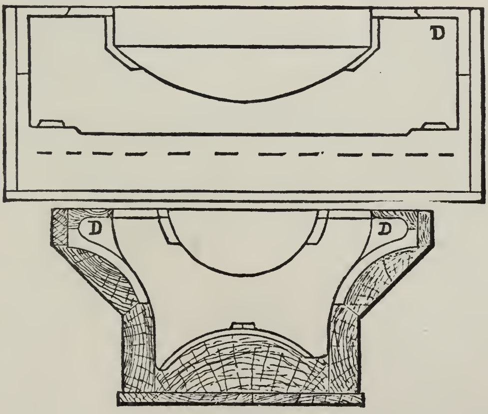


Fig. 90.

Fig. 90 is a side and end section of the stand core-box. It is made just the shape of the inside of the casting required; and all the brackets and pieces, *D*,

which form the feet or bearing surfaces of the cylinder, are loose, and drawn from the core separately.

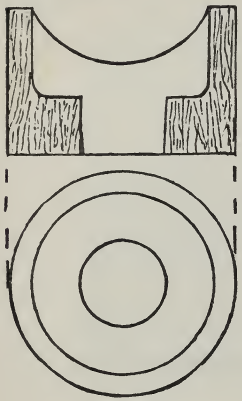


Fig. 91.

A plan and section of the steam-inlet core-box is shown at Fig. 91. It requires very little explanation. It is an open box, and the top made concave to fit the valve-chest body core.

MOULDING.

A good plan of moulding such a cylinder as this is shown at Fig. 92. Many engine-builders object to cylinders being cast horizontally; but in this case the metal which flows up and forms the stand, or foot of the casting, carries

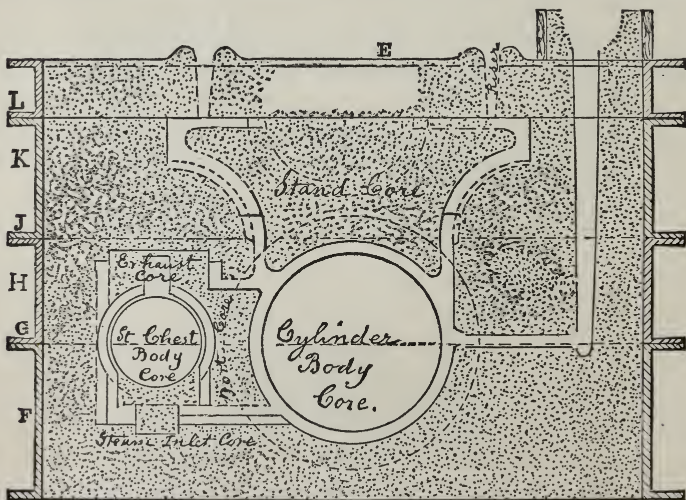


Fig. 92.

off all the dross and dirt from the valve-chest and the

body of the cylinder, and escapes through the four risers shown at *E*.

When starting to mould this cylinder, first take the top section of the pattern of the cylinder and the valve-chest, and place it on a turn-over board, or some other level surface. Then put on the section of flask *F*, ram it up, and turn it over into the proper position, and make the parting at *G;* then put on the bottom section of the pattern of the valve-chest and the body of the cylinder.

The section of flask *H* may then be put in place, and rammed up to *J*, where the parting is made. The section of the pattern which forms the feet of the cylinder should be placed in position, and the flask *K* set on and rammed level with the top of the pattern, and the parting made at *L*. The cope flask may now be put on and rammed up.

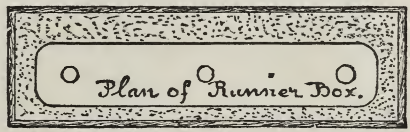


Fig. 92a.

The method of casting the same cylinder vertically is shown at Fig. 93. In this case the end section of the pattern is first set in the lower section of the flask shown in the figure; the flask filled in, and rammed up around the prints, level with the lower edge of the flanges, and the parting made at *M*. The part of the flask *N* is then put in place, and moulded up to *P*, where the parting is made. The main part of the pattern may then be put in position, and the flask *R* put on and moulded level with the top of the flange, and the parting made at *S*. We can then put on the cope, and ram it up. When this has been done, we are ready to open the mould, and draw all the different sections of

the pattern, finish the mould, and close it down. The mould is then opened, and the different sections of the pattern drawn from the sand. When this has been done, we may finish the mould, set the cores, close the mould, make risers and runner-box, and we are ready to cast, as shown in the figure.

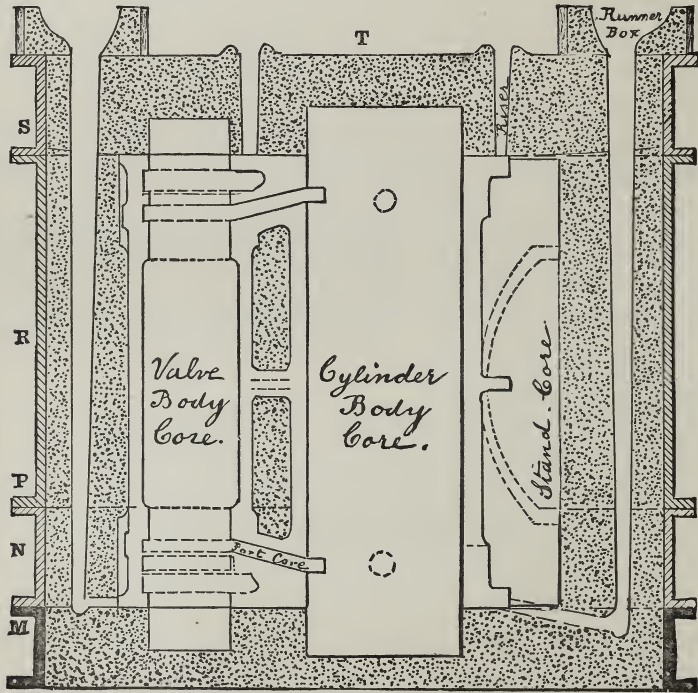


Fig. 93.

When setting the cores, a space of about $\frac{1}{2}''$ should be left between the port core and the cylinder body core. This allows the dirt, which would have a tendency to lodge under the sides of the ports, to pass between the cores, and be carried off by the risers *T*.

CHAPTER XV.

CASTING STEAM-JACKETED CYLINDERS IN GREEN SAND.

In our last article we dwelt to a considerable length upon the different methods of making the pattern and moulding cylinders with piston valves. And before

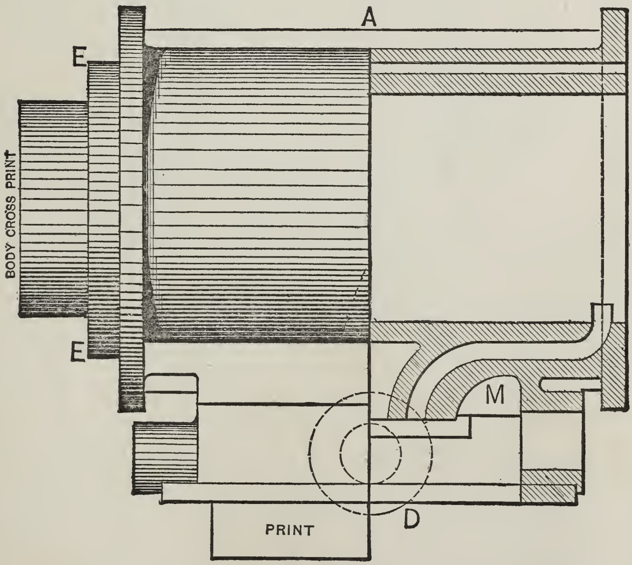


Fig. 94.

concluding this subject of cylinders, I think it will be in order to devote a little time to steam-jacketed cylinders, for the old reliable slide-valve engines; and as the

slide-valve cylinder, in different forms, has run the commercial traffic of the world for years, and is at present in general use on all the marine and locomotive engines, and also on many stationary engines, the best method of making such cylinders is of more than ordinary interest.

Figs. 94 and 95 represent the general drawing of a

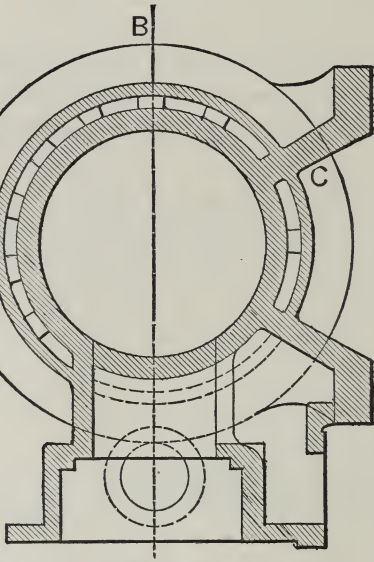


Fig. 95.

steam-jacketed cylinder. The right-hand half of Fig. 94 is a sectional plan of the casting required, and the left-hand half is a plan of the pattern; while Fig. 95 is a section of the cylinder, at the division line *A*.

The pattern for such a cylinder as the one shown should be made to part through the centre, as shown by the dotted line *B*, Fig. 95; and the feet should be made loose, and part from the body of the pattern at

C, Fig. 95. The arc of the circle of the exhaust flange, which projects beyond the flange of the valve-chest, as seen at *D*, Fig. 94, must also be made loose, as it will have to be drawn in towards the centre of the mould after the body of the pattern has been drawn from the sand.

The steam-jacket core print, shown at *E*, Fig. 94, should be 2½″ thick, or in other words it should measure 2½″ from the outside edge of the print to the flange of the cylinder; and the prints for carrying the body core, and also the one for the valve-chest core, should be at least 4″ long. The steam-jacket core must be made in sections; these sections may be made any convenient width, say from 4″ to 8″.

Fig. 96.

A side and end section of the steam-jacket core-box is shown at Fig. 96; and, as will be seen by the drawing, it is made open on the top, and at each end the bottom is cut down the thickness of the metal required in the body of the cylinders. The object of this is to have the ends of the jacket cores project over to the body core, as shown at *F*, Fig. 103, and thus fill up the space between the jacket and the body cores, which would otherwise have to be filled with green sand, after the jacket cores were set in the mould. The bridges, which connect the steam-jacket with the body of the cylinder, are made by setting pieces in the core-box, as shown at *G*, Fig. 96.

A plan and section of the valve-chest core-box are

shown at Fig. 97. For such a cylinder as this, only a half box is wanted; and it must be the full width of the valve-chest, by half the depth. For instance, if the inside of the valve-chest is 12″ by 26″, the box must be made 6″ deep and 26″ wide. Now, it sometimes happens that the centre of the valve-chest is not level with the centre line of the cylinder; and in such cases it is necessary to make two boxes, one for the upper and one for the lower section of the core, as in all cases the core must be jointed at the centre line of the cylinder, or the parting of the mould.

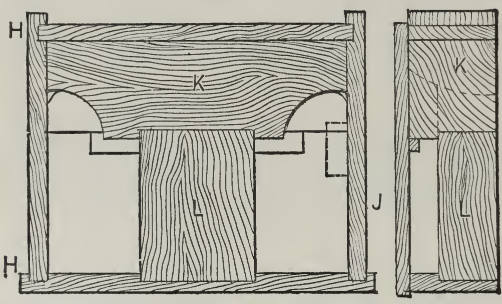


Fig. 97.

A good way to make the box shown in the figure is as follows. First, get out the lumber for the sides, ends, and bottom, and plane it smooth and true on one side and one edge. When this has been done, the sides may be gauged to the proper width, and then checked and screwed together, as shown at *H* and *J*. The piece marked *K*, which is made to form the valve-seat, and lighten the metal on the outside of the port cores, as shown at *M*, Fig. 94, must be loose, and an easy fit. The piece *L*, which may be called the print for carrying the port and exhaust cores, is also loose, and should

be gained into the end of the box, and the piece *K*, as shown in the figure. Now, when the core has been made, *L* and *K* can be drawn from their places, and the impression filled with sand. This is done for the purpose of supporting the centre and edges of the core while it is being turned over, and the sand can be easily removed when the core has been dried. Then cover the core with a dry plate, turn it over, and lift off the box, finish the core, and it is ready for the oven.

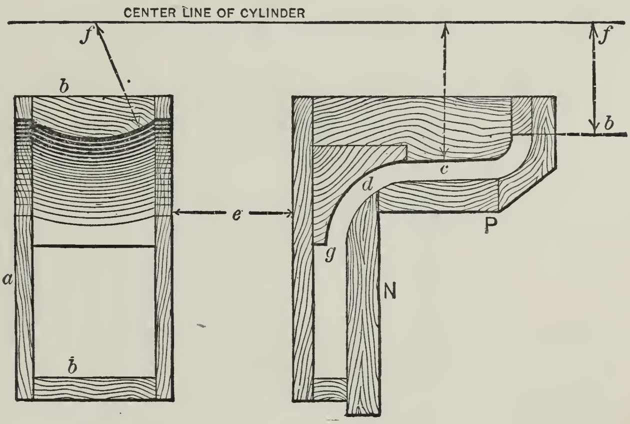


Fig. 98. Fig. 99.

A sectional view of the port core-box is shown at Fig. 99, and a plan of the same, with the cover or loose pieces *N* and *P* removed, is shown at Fig. 98. The manner of putting this box together can be seen by the drawings, and therefore requires no explanation; but the method of getting the proper forms and curves is of infinitely more importance. It is done as follows: The face of the end *b* should be struck with a radius equal to the distance from the centre line of the cylinder to the outside of the body core, or bore of the cylinder,

as shown at *f;* and the face *c* should be struck with a radius equal to the distance from the centre line of the cylinder to the face of the core; and the inside of the cover *P* is struck with the same radius, plus the thickness of the core. The curve *d* must be an arc of a circle, struck with radii from the centre line of the cylinder, and graduating from *c* to *e*. The sides and ends *a* and *b*, Fig. 98, should stand the thickness of the core above the bottom of the box, and at a point equal to

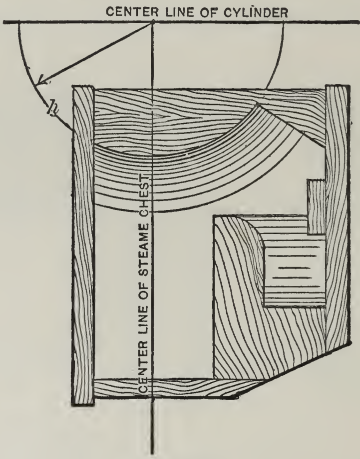


Fig. 100.

the distance from the centre line of the cylinder to the face of the valve-seat; the bottom is cut back the thickness of the metal required between the port and exhaust cores, as shown at *g*, Fig. 99. For the better understanding of this, it will be well to refer to Fig. 102, where the cores can be seen in the mould.

The left-hand half of the exhaust core-box is shown at Fig. 100, and the drawing almost explains itself. The arc of a circle marked *h* is struck with a radius

equal to half the diameter of the body core, with the thickness of the metal required between the cylinder-body and exhaust cores added; and, in like manner, the bottom and sides of the box should correspond with the shapes of the same surfaces of the exhaust, as shown on the general drawing, Figs. 94 and 95.

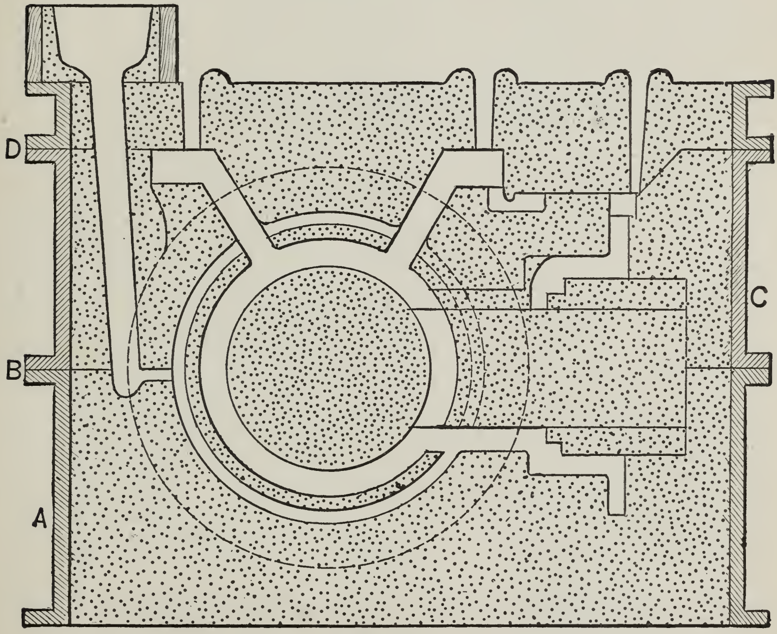


Fig. 101.

MOULDING.

The method of moulding is shown at Figs. 101, 102, and 103. Fig. 101 is a sectional end view of the mould, when closed and ready to cast; Fig. 102 is a plan of the mould through the centre of the cylinder, showing all the cores set in their proper position; and Fig. 103

is a plan of the mould when closed, showing the pouring-basin, and also the location of the risers, or flow-off gates, shown at *R*.

The first operations when moulding this cylinder are

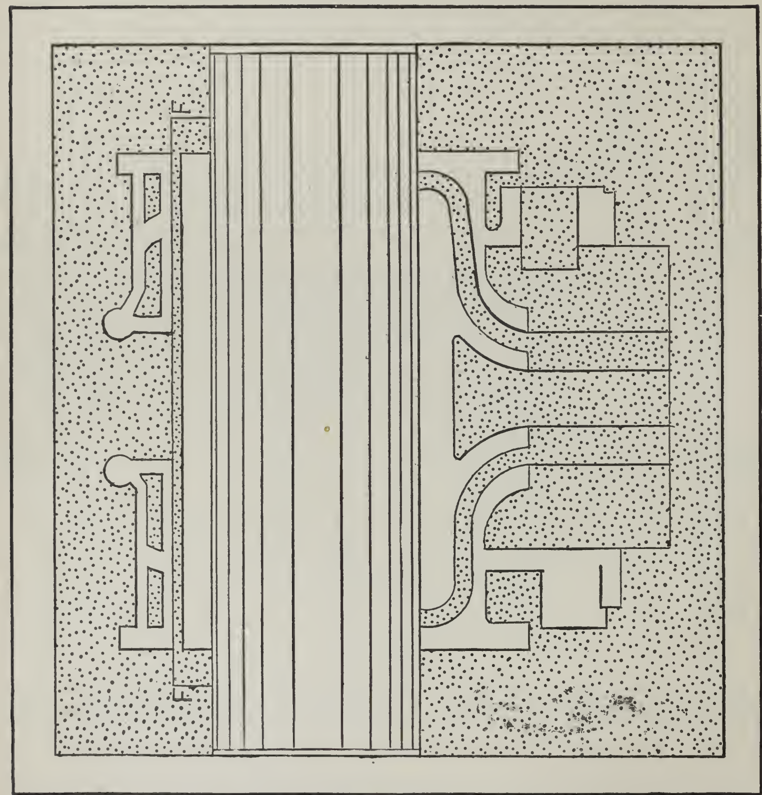


Fig. 102.

much the same as illustrated in the preceding chapter; and, in like manner, the metal which flows up and forms the feet and flange of the exhaust opening, carries off all the dross and dirt from the face of the valve-seat and the body of the cylinder and escapes through the

risers, or flow-off gates, shown at Fig. 103, and that insures good solid metal in all the working parts of the casting.

When starting to mould this cylinder, first take the top section of the pattern of the cylinder and valve-

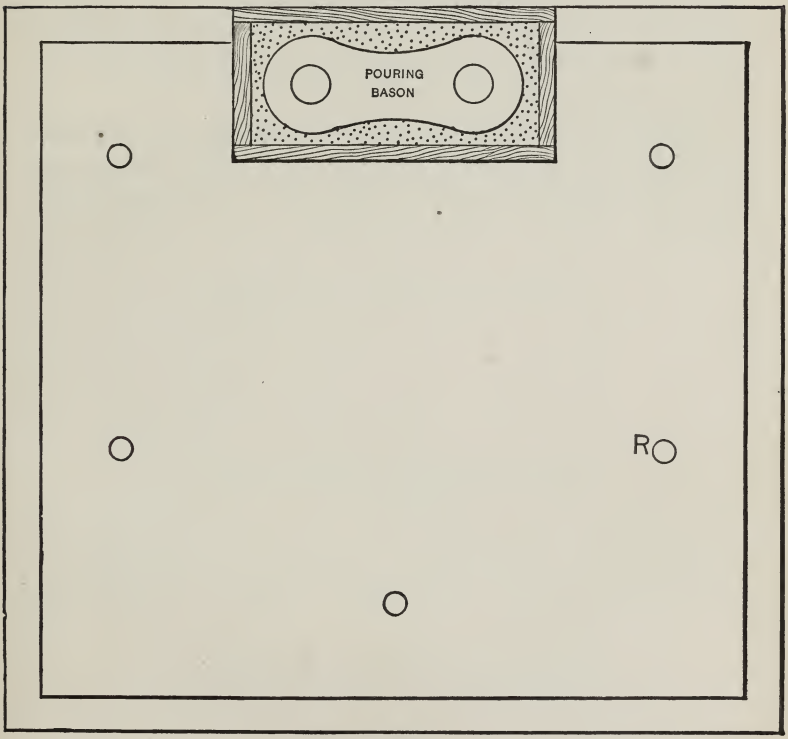


Fig. 103.

chest, and place it on a turn-over board. Set on the section of flask *A*, ram it up, turn it over, and put it in proper position, and make parting at *B;* next set on the bottom section of pattern of the valve-chest, and the body of the cylinder, including the feet. The sec-

tion of the flask marked *C* may then be put in place, and rammed up to *D*. The parting is now made along the top surface of the feet and between the same, and cut down to the exhaust, as shown in the figure. When the cope is in position, and rammed up, the mould is opened, and the different sections of the pattern drawn from the sand. After this has been done, we may finish the mould, set the cores, as shown at Fig. 103, and then close it down, as shown at Fig. 102.

Should it be deemed well to cast such a cylinder vertically, we may follow (with very slight variations) the same method shown at Fig. 93, in the preceding chapter.

CHAPTER XVI.

CASTING LARGE CYLINDERS IN LOAM.

No other method of making castings requires so little pattern-making as loam-work. In fact, we can almost say that, in this branch of the business, the regular pattern-maker is dispensed with entirely.

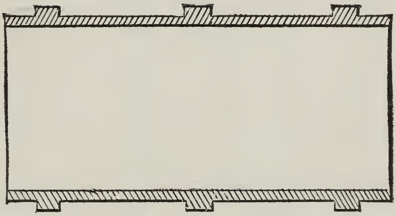


Fig. 104.

Fig. 104 is a sectional elevation of a large cylinder, intended to be cast in loam; and, in this case, all that

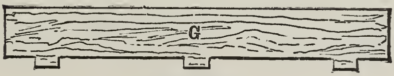


Fig. 105.

is wanted from the pattern-shop is the loam-board *G*, shown in Fig. 105. It might be called a templet for forming the outside of the casting required.

MOULDING.

Having made the proper excavation in the floor, and

set the spindle-step *A*, Fig. 106, get a sufficient number of stands, such as are shown at *B*, and set them quite solid and level in the bottom of the mould. Upon these place the strong cast-iron plate *C*. The outside diameter of this plate should be equal to that of the

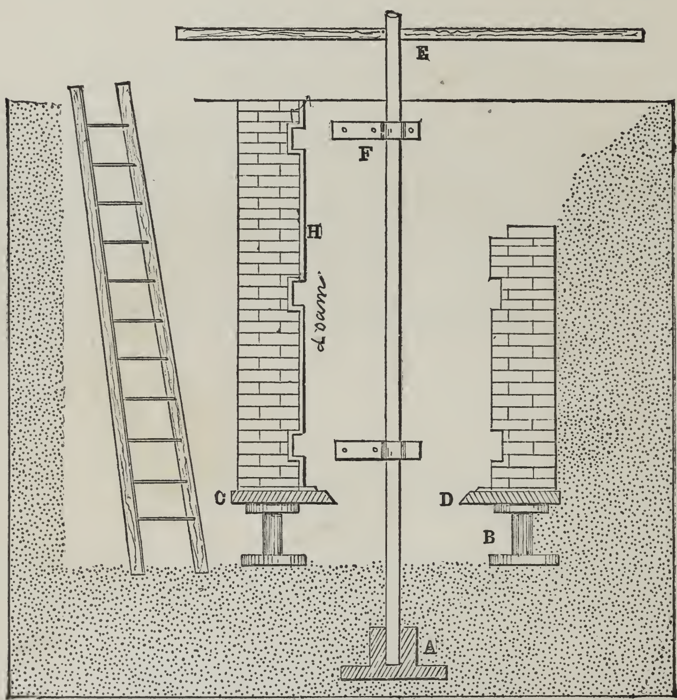


Fig. 106.

brick wall required for the mould, and the hole in the centre about 6″ or 8″ smaller than the inside diameter of the cylinder. The inside edge should have an angle of about 45°, as shown at *D*.

Having thus prepared a good solid foundation for the brick wall, the spindle is set plumb, and held in

position by the brace *E;* the loam-board *G*, Fig. 105, being bolted to the arms *F*. We are now ready to build the brick wall, using the loam-board for a guide as to plumb, inside diameter, shape, etc. When the wall has been completed, it is lined with a coating of loam, shown at *H;* the board *G* being again used for the purposes mentioned above.

When this has been consummated, and the loam-

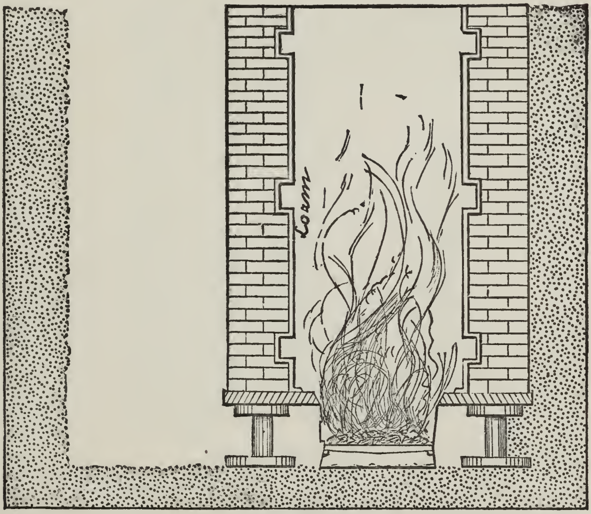


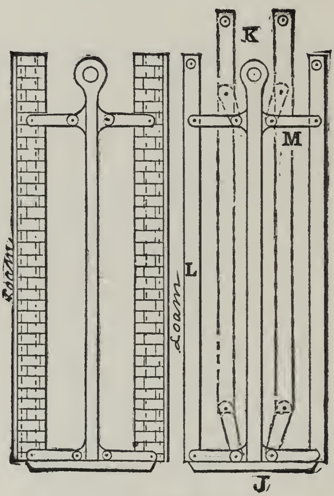
Fig. 107.

board and spindle removed, we are ready to dry the mould. A good plan to do this is shown at Fig. 107, and requires very little explanation. The heat dries the mould as it rises from the fire, which has been kindled in the temporary furnace shown in the figure.

The method of making core-irons is shown at Fig. 109. The bottom plate *J* is made to fit the hole in the centre of the foundation plate *C*, Fig. 106. The

centre or lifting-bar *K* is made fast to the plate *J*, and the side wings *L* are held in position by the hinged arms *M*. The side wings *L* should be about $\frac{3}{4}''$ thick, and any convenient width. When the brick core has been made, and coated with loam, as shown at Fig. 108, it is ready for drying.

After the core and mould are both thoroughly dried,



Figs. 108 and 109.

the fire is taken out of the bottom of the mould, the core is set in position, and the mould closed.

Now, when the cylinder has been cast, and the metal just set, the side wings *L* may be drawn out of the brickwork of the core up into the position indicated by the dotted lines, Fig. 109. This allows the core to be pressed in by the shrinkage of the metal, and thus avoids the danger of breaking the casting.

CHAPTER XVII.

TOOL WORK. — PATTERN-MAKING AND MOULDING LARGE FACE-PLATES.

We now come to another important class of work, viz., machine tools; and, for the first example, we will take the large face-plate, shown in section and elevation at Figs. 110 and 111.

The + marks are intended to represent the bolt-holes, which must be made square and cored out. Although not shown on the drawing, a number of these cores must be set between all the arms: this is in order to allow the lathe-man to put in the requisite number of bolts, to hold the work securely to the face-plate. A T-shaped core runs through the arm from the bore of the hub to the outside of the rim. An opening for inserting the bolts through the back of the arm is shown at *a*, Fig. 111. All the projections *d*, Fig. 111, also have a T-shaped core in the centre, as shown at *e* in the same figure.

PATTERN-MAKING.

For the purpose of casting such a large face-plate as this, the sections of the pattern illustrated in the annexed figure answer the requirements of the moulder quite as well as a full pattern, inasmuch as they are lighter, and consequently easier to handle and draw from the sand.

Fig. 112 represents the pattern of the hub. To make this pattern, we get out a number of pieces of 2″ plank, joint the edges, and glue them all together. The pieces, when thus jointed and glued together, should make one piece so large that the disk *A*, or bottom of the pattern, could be cut out of it. We mount this disk upon a lathe-chuck, put it in the lathe, face it off, and build up with segments the rings *B* and *C*. When these rings have been built up to within about $1\frac{3}{4}''$ of the finished depth of the pattern at the bore, they must be covered with another disk made of 2″ lumber. By referring to the figure, it will be seen that this disk has a bearing of only about $\frac{3}{4}''$ on the inside edge of the ring *C*, thus allowing a good margin or bearing for the segments, with which we build up the balance of the ring, or outside of the pattern. These segments cover the end grain of the wood, and so prevent the pattern from warping or changing its shape by shrinkage. When the pattern has been built up in the rough, as described, and the glue thoroughly dried, it may be turned to the proper size and shape.

A plan and side elevation of the arm pattern is shown at Figs. 113 and 114. A full set of these arms will be required, and can be made in the following manner.

First prepare the wood for the bottom or web part of the arms; it should be of a length sufficient to reach from the hub to the rim, equal in thickness to that of the web, and about two or three inches wider than the arm. The inside end should be cut to fit the hub, and the outside end to fit the rim. Then run a gauge mark through the centre, and on each side of this gauge mark draw lines to represent the edge of the arm. Now rip out the stuff for the arms, dress it

Fig. 116.

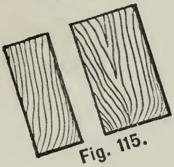


Fig. 115.

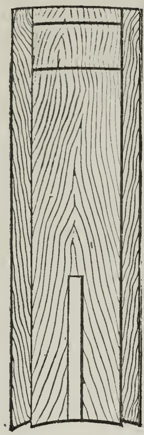


Fig. 114.

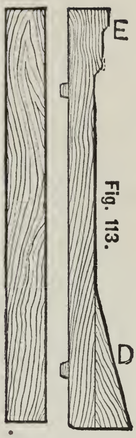


Fig. 113.

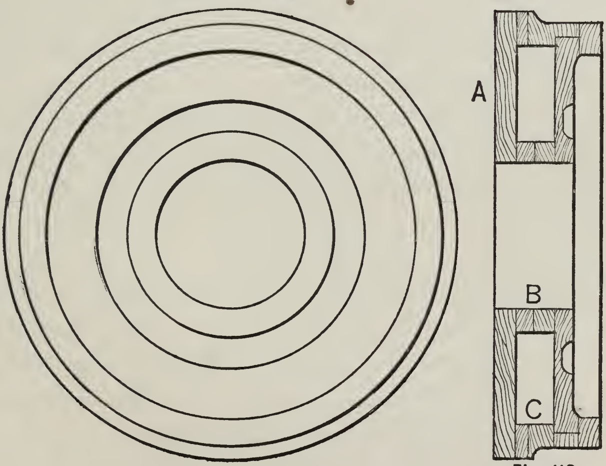


Fig. 112.

Fig. 117.

off to the desired width and thickness, put on the rib *D*, fitting pieces *E*, and cut the ends to fit the hub and rim. It is afterwards set to the representative lines on the web part, held firmly with hand screws, and when in that position the holes are bored for the dowel pins shown in Fig. 113.

Fig. 114 is a plan and side elevation of the part *d*, shown on the general drawing.

Fig. 115 is a plain block, made to the proper size and shape, and calls for no further explanation except that a full set will be needed; in the present example, sixteen had to be made.

One view of a section of the rim is shown at Fig. 116. These sections must be long enough to reach from centre to centre of the arms, and of a sufficient number to make a complete circle of the rim when set in position in the mould.

A plan and end section of the arm core-box is shown at Fig. 117. The core *e*, Fig. 111, can also be made in this box by stopping it off to the proper length.

MOULDING.

The method of moulding this face-plate is shown at Figs. 118 and 119. Fig. 118 is a plan showing the mould at different stages of procedure with the work; and Fig. 119 is a sectional view, with the cores all set, and the mould closed and ready to cast.

As shown in the engraving Fig. 119, this face-plate is moulded face down, which method insures sound metal, and a smooth surface on the face of the casting.

When starting to mould this or any casting of a similar form, we first make a hole in the floor of the foundry deep enough to allow for a good bed for the

mould, which should be made with a layer of from

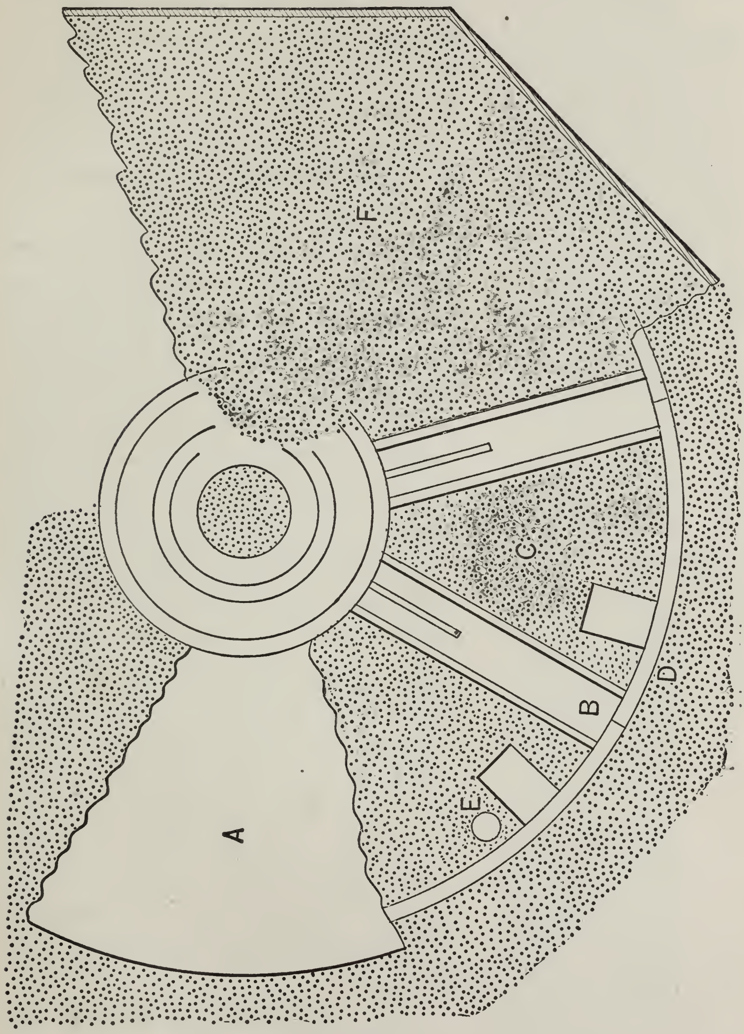


Fig. 118.

three inches to five inches of cinders or coke, covered

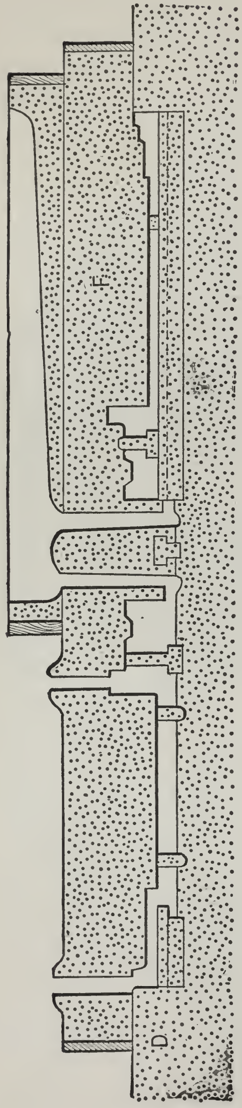


Fig. 119.

with about the same thickness of sand. This bed is then swept off smooth and level, as shown at *A*, Fig. 118; the hub pattern placed in the centre of the bed; and the bottom or web sections of the arm patterns and the segments for the rim are all set in position as shown at *B*, Fig. 118. Fill in the sand, and mould up the thickness of the web between the arms as seen at *C*, and the full depth of the rim on the outside as shown at *D*, Figs. 118 and 119. The upper or back sections of the arm patterns, and all the *scroll bosses* and projections shown at *E*, may then be set in place, and the cope put on and moulded up, as shown at *F* in both the engravings. Now lift the cope off, and draw all the patterns. The thickness of the web of sand standing between the arms as shown at *C* — which has answered instead of a pattern — must now be swept out, and the whole surface of the mould finished, and well vented downwards to the bed of cinders or coke.

After finishing the mould, set the cores, close down the cope, and prepare to cast as shown at Fig. 119.

CHAPTER XVIII.

THE LATHE SPINDLE.

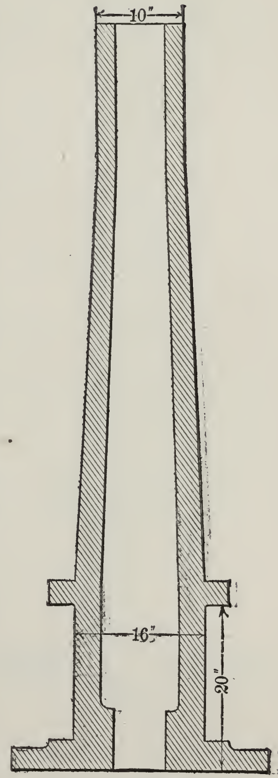


Fig. 120.

FIG. 120 is a sectional elevation of a large lathe spindle; and in this chapter we will try to illustrate a good way to make the pattern, and mould it or any other similar casting. This class of work should always be cast vertically; and, as it is necessary to have good sound metal in the main bearing, it should be cast with the large end down.

The method of making the pattern is illustrated at Fig. 121. One half of the engraving represents the pattern when finished and put together, and the other half is a sectional view showing how each section of the pattern is built. The pattern was made in four sections, and parted at *A*, *B*, and *C*.

To make the large flange section marked *D* in the engraving, we first prepare a number of pieces of $1\frac{1}{2}''$ planks, and glue them together. When these

pieces have been put together as directed, the piece should be large enough to allow us to cut out a disk about ½″ larger in diameter than the finished edge of the pattern. The disk is then mounted on a face plate, put in the lathe, and faced off. The balance of the thickness is then built up with two or more courses of segments as shown at *C*. When the glue has become thoroughly dried, the pattern may be turned to the finished size. After the pattern has been turned to size and taken out of the lathe, there should be a number of stout screws put through the disk into the first course of segments. These screws will assist the glue in holding the joint and prevent the pattern from changing shape and warping.

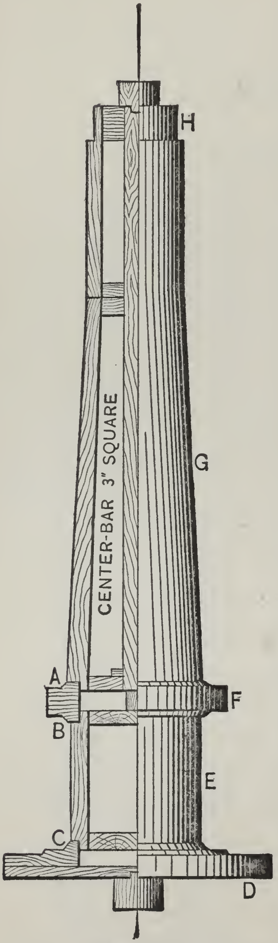


Fig. 121.

We will now proceed to make the section of the pattern marked *E* in the engraving. This is done by what is called staving or lagging, and is performed in the following manner: —

As in Fig. 122, with a radius equal to half the diameter of the pattern, less the thickness of the wood which we intend to use for the staves, draw the circle *a;* divide this circle into as many equal parts as there are to be staves in the

pattern; from these points draw the radial lines *b c*. If lines are drawn cutting the intersections of the radial lines with the circle, we produce a rectilinear figure having as many sides as the circle *a* has been divided into parts, which will be the size and shape to cut out the heads or pieces to which the staves must be fixed. The heads should be cut out of lumber sufficiently thick to stand the nails or screws which hold the staves in position, and they should also have a stout batten glued and screwed across the back. This will give additional stability to the pattern, and allow

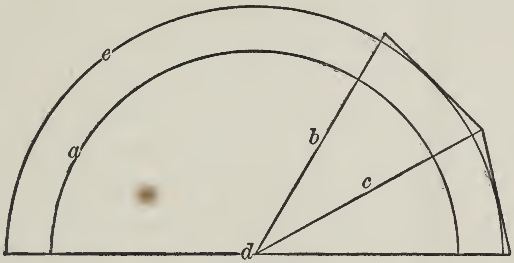


Fig. 122.

the moulder to insert rapping irons without any danger of splitting the heads. To determine the width and bevel for the staves, we take *d* as a centre, and draw the circle *e*, or an arc thereof, a little larger in diameter than the intended pattern; join the radial lines *b c*, touching the line of the circle, and we have the proper width and bevel for the staves when finished: so that, when preparing the staves in the rough, it will be necessary to cut them about an eighth of an inch wider, which will be ample stock for jointing the edges. The staves should be cut off at least half an inch longer than the finished pattern, the extra length being easily cut off in the lathe.

The staves may be prepared rapidly by tilting the saw-table to the angle required for the staves, and then adjusting the gauge to the correct width. Each time a stave is sawed, the board is reversed. This method not only effects a saving of time, but entails no loss of lumber. In building the pattern, each stave should be jointed on the edges and glued to its fellow and to the heads, to which latter they should also be nailed or screwed.

When the pattern has been thus built up in the rough, it may be put in the lathe, turned to the finished diameter, and the rabbet cut on the ends to fit the chambers on the flange *D* and the collar *F*, as shown at *B* and *C*, Fig. 121. The distance between the shoulders of the rabbets should be equal to the distance between the fillets on the flange and collar; for the fillets must be on the latter parts, in order to avoid cross-grain. The collar *F* being a plain ring, it may be built up with segments, and turned to the proper size and shape in the usual way of doing such work.

We have now come to the last and most important section of the patterns, viz., the cone; and, as this is the only chapter in which the cone has been introduced, we will take it as an example or illustration of the method of building cone-shaped patterns.

The first step is to make a full-sized sketch of the pattern, or a portion thereof large enough for us to determine upon the sizes and number of pieces of wood to be used in its construction.

By referring to Fig. 121, it will be seen that a considerable portion of the small end of the pattern has to be made parallel; and, in order to save lumber and time in turning, the staves are made in two lengths. The

size and bevel of the staves for the parallel part of the pattern may be determined in the same manner as illustrated in Fig. 122.

At Fig. 123 we illustrate the method of obtaining the size and bevel of the staves for the body of the cone.

With a radius equal to half the diameter of the pattern at each end, less the thickness of the lumber that is to be used for the staves, describe the semicircles *e f*. Divide the semicircle *f* into half as many equal parts as there are to be staves in the pattern. From these points draw radial lines, as shown. If we now draw lines cutting the intersection of the radial lines with

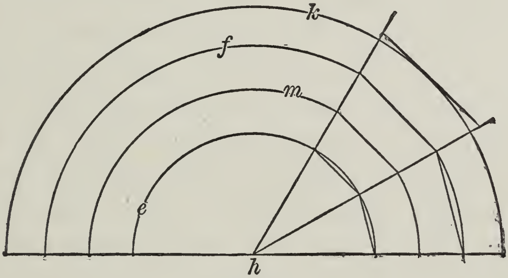


Fig. 123.

the semicircles *e f*, we have a rectilinear figure which will represent the size and shape to cut the heads or end pieces.

We now take *h* as a centre, and describe the semicircle *k m*, or an arc thereof, a little larger than the finished diameter of the pattern; join the radial lines, touching the lines of the semicircles *k m*, and we produce an outline of the finished size and shape of the staves at each end, as shown in the figure, and the length can be taken from the full-sized sketch. Allow about half an inch in the length for cutting off in the lathe.

Get a piece of board, and cut a jog in one edge corresponding in length and taper to that of the staves. If we now place the board from which the staves are to be cut in this jog, and pass the whole across the circular saw, a stave will be cut off. Reverse the board endwise, and proceed as before until a sufficient number of staves have been cut off.

The next step is to prepare a centre bar, upon which to build the pattern. This bar should be about 3″ square, and of sufficient length to reach through both the parallel and tapered parts of the pattern, as shown in Fig. 121.

Having prepared the centre bar as directed, we cut a square hole through the centre of the head piece, just large enough to allow the bar to be put through. The head pieces are then put on the bar, and set in the position shown in the figure, and held firmly with nails or screws. The staves should now be glued and nailed on. When the glue has dried, the pattern thus built up in the rough is put in the lathe, and turned to the finished size. I may add, that, in addition to the required length of the casting, the pattern should have about four or five inches allowed for riser head, as shown at *H*. The prints should be loose, and held in position with dowel-pins.

A half-core box should be made for this pattern; but it will be unnecessary to describe its construction in detail, as the process is much the same as that of building the pattern, the staves being arranged on the inside of the heads instead of the outside, and worked out with a round-sole plane.

MOULDING.

The method of moulding is shown at Figs. 124, 125, and 126. Fig. 124 is a sectional view of the mould

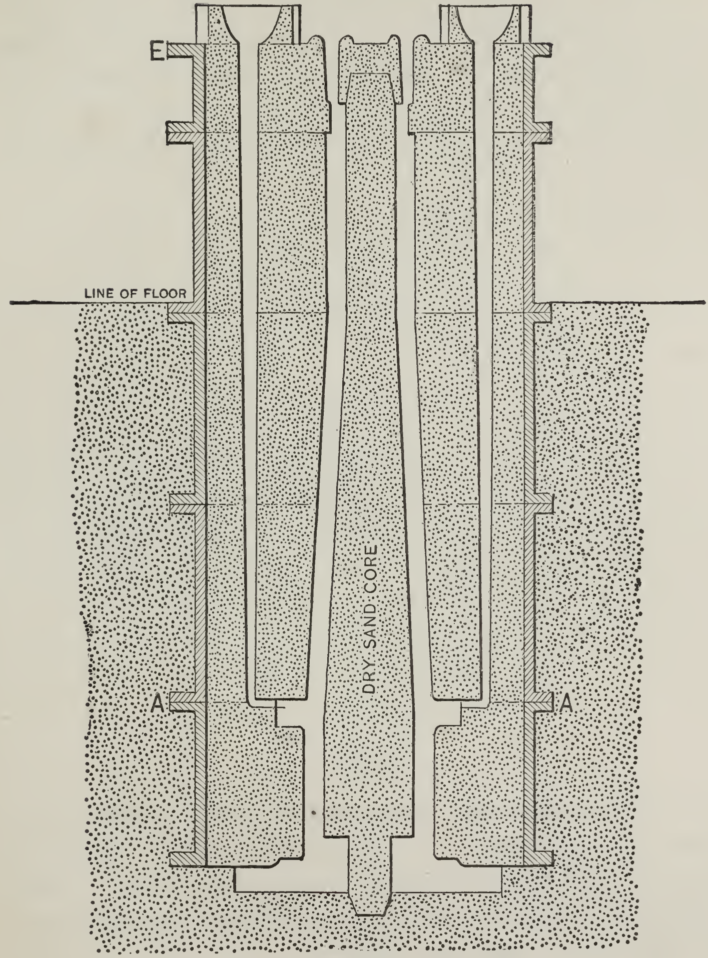


Fig. 124.

when closed and ready to cast; Fig. 125 is a plan

through *A*, showing the feed-gates and other parts of the mould, while Fig. 126 represents a plan of the pouring-basin.

As will be seen by the engraving, the greater part of the mould is made in a pit; so that the first step is to make a hole in the floor the requisite depth, and wide enough to allow us to work on the outside of the flask. When the bed for the mould has been made in

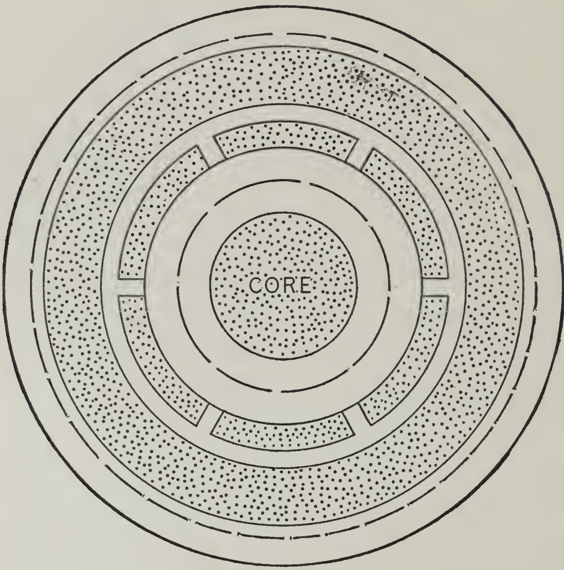


Fig. 125.

the bottom of the pit, the pattern is set in position; and then the first section of the flask is put on, filled in, and moulded up to *A*, where a parting is made. Each section of the flask is thus put on, filled in, and moulded up separately, until we come up to *E*. The sections are then lifted off separately, finished, and set in the oven to dry. When every section has been thoroughly

dried, the two bottom sections may be lowered into their place in the pit. The core must now be set in place, as it would be hardly possible to lower it down through the small opening in the centre of the third section of the mould, without injuring either the core

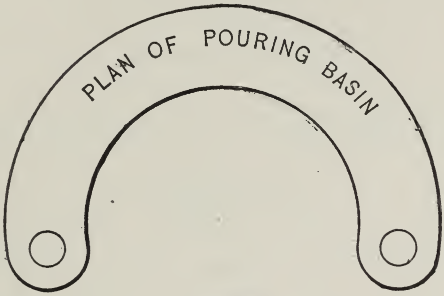


Fig. 126.

or the mould, or perhaps both. The other three sections of the mould may now be set on, and the pit filled in around the outside of the flasks, and rammed up level with the line of the floor, as shown at *A*.

CHAPTER XIX.

THE HEAD-STOCK.

THE engravings shown in this chapter represent the

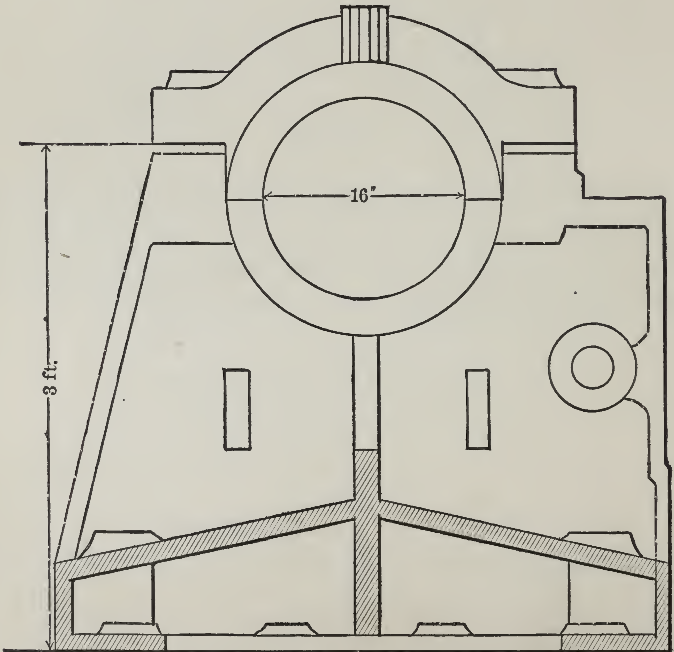


Fig. 127.

head-stock of a fourteen-feet swing pit-lathe built by the Beckett & McDowell Manufacturing Company,

Arlington, N. J.; and it will answer for a good illustration of this class of pattern-making and moulding.

Figs. 127 and 128 are end views, showing the form and thickness of the metal, and the bearing-caps set in place. Figs. 129 and 130 are the plan and side eleva-

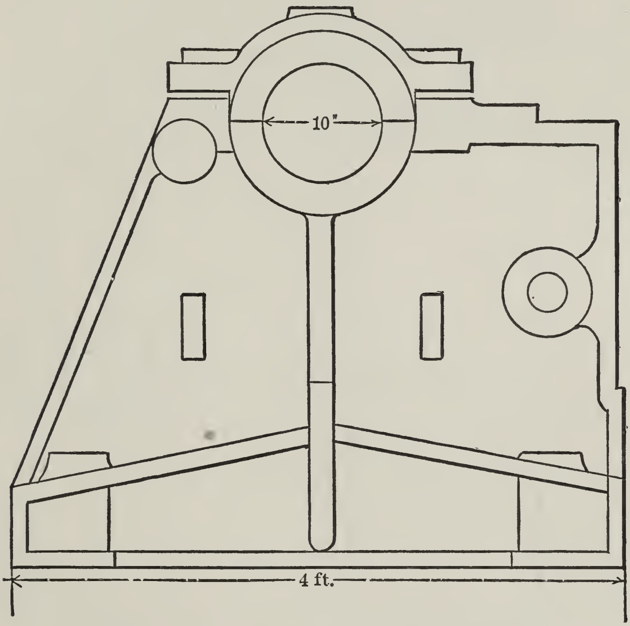


Fig. 128.

tion of the casting, and they also serve to illustrate the method of constructing the pattern.

PATTERN-MAKING.

Although this pattern is moulded with the bearings down, as shown at Figs. 131 and 132, it is better to make it in two pieces, and part it through the centre of the bearings and the rib *A*, Fig. 130, as it will be

lighter to handle; and, when set in position to mould,

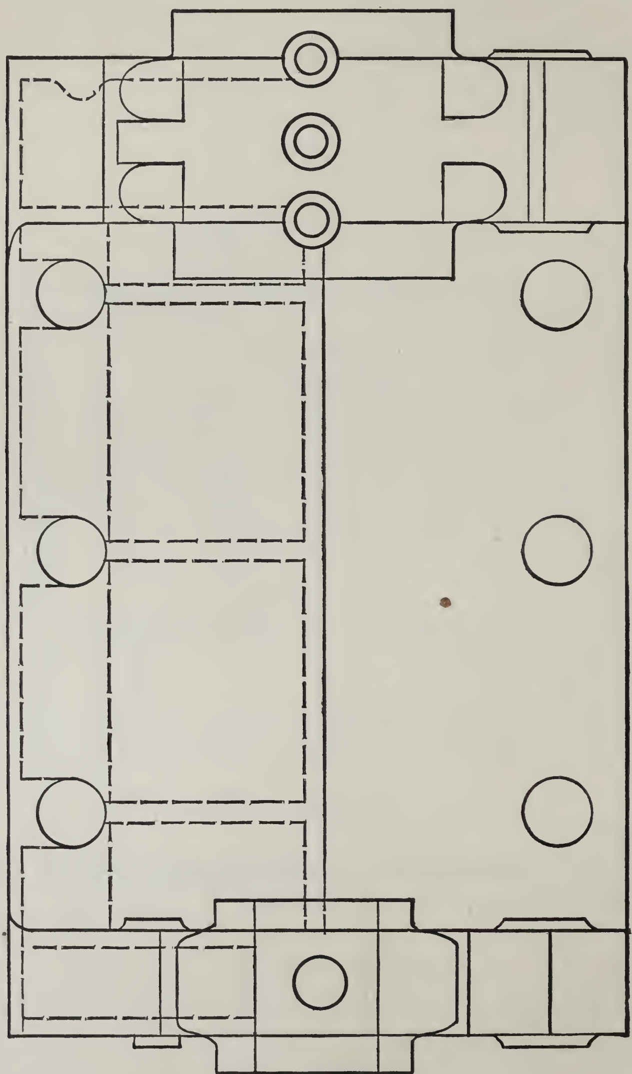


Fig. 129.

it can be fastened together with strong bars across

the ends, on the inside of the pattern, and held with

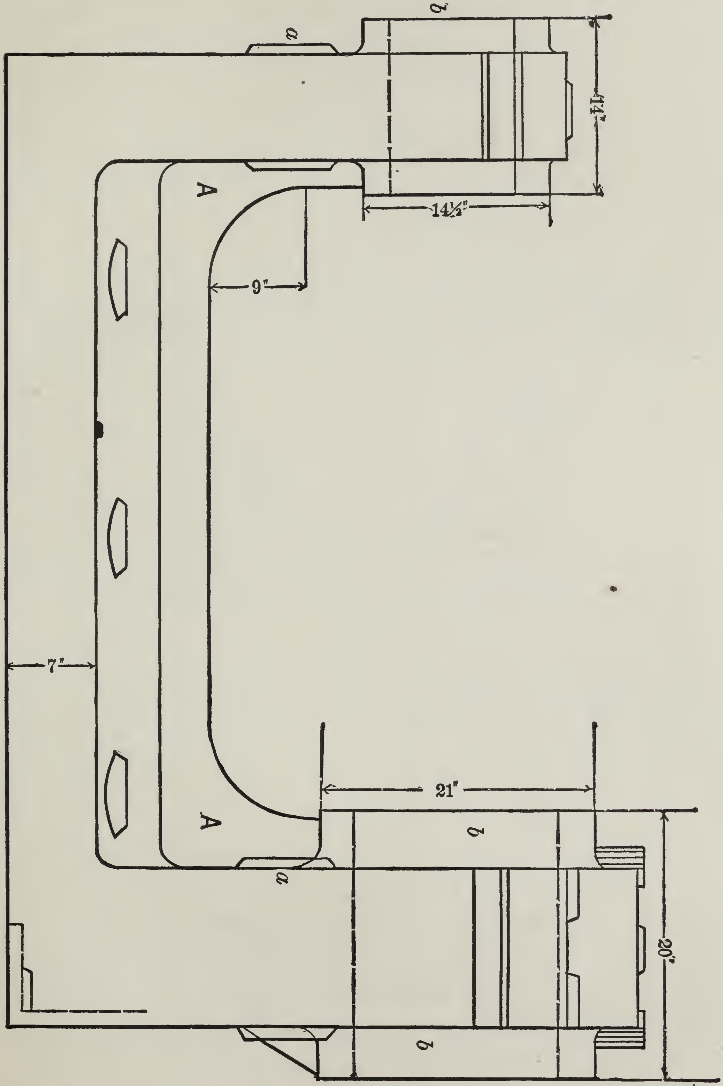


Fig. 130.

4″ No. 20 screws put in from the outside. Then, when

the pattern has been moulded and drawn from the sand, it can be taken apart, and the rib *A* taken off and used for finishing or mending the mould, in case it should be damaged or broken while drawing the pattern. All the bosses *a* and extensions *b* for giving additional length to the bearings should be loose, and held in position with slack dowel-pins that may be easily taken out with the hands.

By referring to Fig. 132, it will be seen that the bearings are made with dry-sand cores, so that it will be necessary to make two core-boxes of different size.

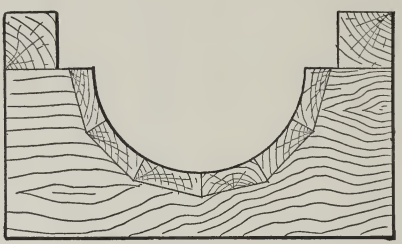


Fig. 131.

A sectional end view of one of these boxes is given at Fig. 131, and the reader will comprehend at a glance how it is constructed. The inside of the casting must, of course, be cored out; and, as shown at Figs. 132 and 133, the core is in twelve sections, two for each end, and eight for the base of the casting. The core-boxes ought to be so constructed that only three will be required to make all the cores, one for each end, and one for the base. The boxes for the end sections should be originally made to suit the section marked *A*, Fig. 132. The part marked *B* must be loose, and should be held in position with screws or dowels. Then, when the core has been made, *B* must be taken out, and another piece

set in the box at the correct angle, to stop off the core for the other section as required. The base core-box is first made to suit the four middle sections, and loose pieces put in to stop off for the end sections.

MOULDING.

The method of moulding this head-stock is shown at

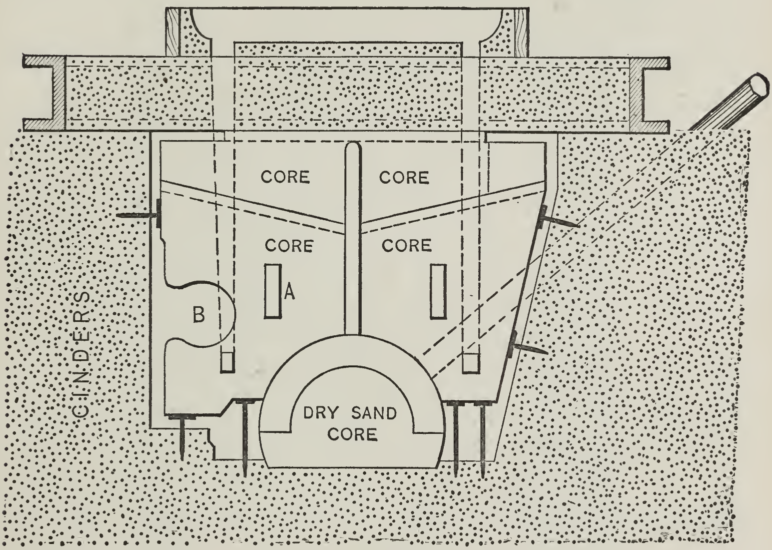


Fig. 132.

Figs. 132 and 133. Fig. 132 is a sectional view, and Fig. 133 represents a side view of the mould.

Both the figures show the cores set in position, and the mould closed and ready to receive the metal.

Having made the proper excavation in the floor, the bottom must be covered with a layer of cinders about four or five inches thick, and then five or six inches of sand, and upon this make the bed for the ends of the pattern.

The pattern may now be set in place, and the centre and sides filled in with sand and cinders, and moulded

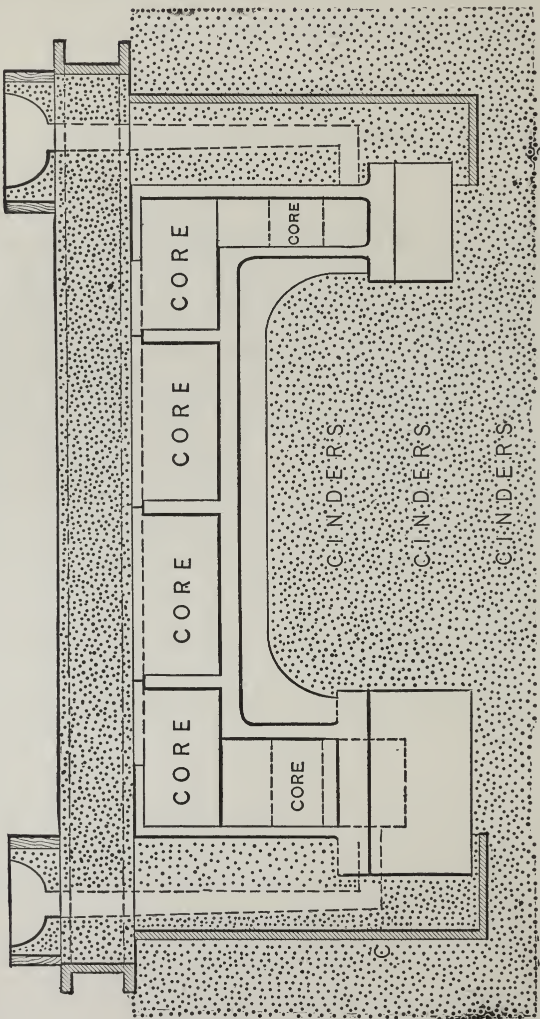


Fig. 133.

as shown in Fig. 133. The centre of the mould should

be well vented downwards to the cinders, which will allow all the gas to escape through the $3\frac{1}{2}''$ pipe shown in Fig. 132.

The sides of the mould should be rammed up square with the ends and level with the top of the pattern, leaving an opening of from two to three feet at each end. Cast-iron draw-back plates may then be set in the positions shown at *C*, and rammed up, making the two feed-gates, as shown in both the figures. After the cope flask has been placed in position and rammed up, as shown, it may be lifted off, and the ends of the mould drawn back and lifted out, finished, and set to dry. Having taken off the cope and ends of the mould, as stated, the body of the pattern can be drawn from the sand, and any loose bosses or facing pieces remaining in the mould can be drawn in towards the centre.

The mould may be dried in a very similar manner to the one shown at Fig. 148, Chapter XXI.

When the mould has been dried and finished, the cores may be set in place. The cores for the ends and base of the casting are set on chaplets, as shown at Fig. 132.

The mould may now be closed, weighted, and made ready to cast.

CHAPTER XX.

MINING-MACHINERY. — CASTING HEAVY MORTARS FOR STAMP-MILLS.

At Fig. 134 we have a front elevation and end section of a wet-crushing silver-mortar. The right-hand half of the elevation shows the front of the casting, and the left-hand half is a front view of the pattern.

The pattern should be made in one piece, or, in other words, it should have no partings or loose pieces. The front, back, and ends must be made of good dry 2″ lumber, well glued, and also held with 3″ and 4″ No. 12 screws. The inside of the pattern should be well bridged and braced with strong common lumber.

The print *A*, for carrying the end of the green-sand or body core, should be at least 4″ long; and as the branch (where the ore is fed in) on the back of the mortar requires a dry-sand core, it is well to carry the print over, as shown by the dotted lines.

Now, by referring to Fig. 137, it will be seen that the span *B*, Fig. 134, between the projection on the front of the mortar and the bottom flange, is made with a dry-sand core, so that the front of the projection must be carried down to the bottom of the pattern to form the print, as shown by dotted lines, Fig. 134.

Now, as an end section of both these cores can be seen in the mould, at Fig. 137, it is not necessary to

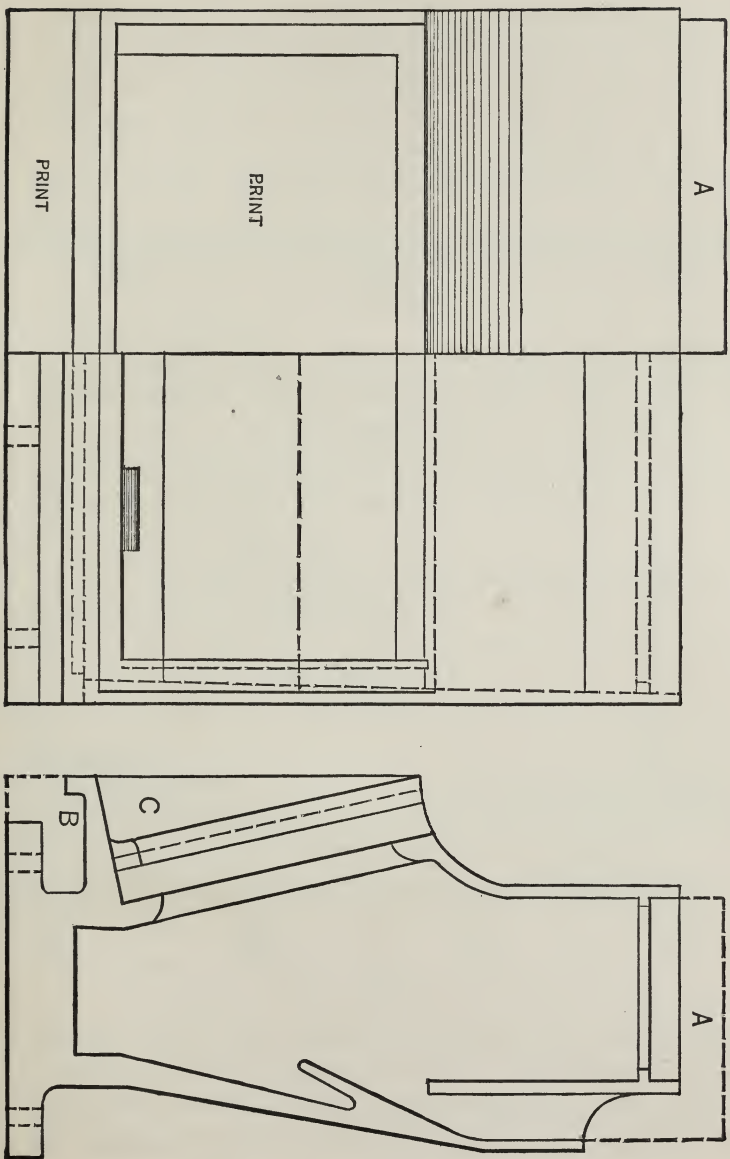


Fig. 134.

give any other illustration, further than to say that the branch core-box is, of course, open on the top, and a strickle-board used to scrape the core-sand off level with the ends and side of the box; and the core *B* is

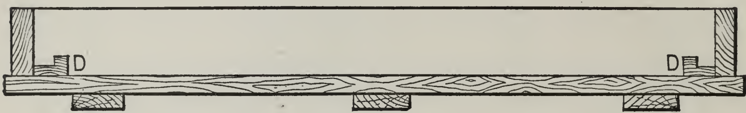


Fig. 135.

made in a plain square box, with a piece the shape of the lip on the projection, and the flange on the bottom of the mortar set in the proper corners.

When the projection on the front of the mortar is very long, it is better to make a flat dry-sand core the

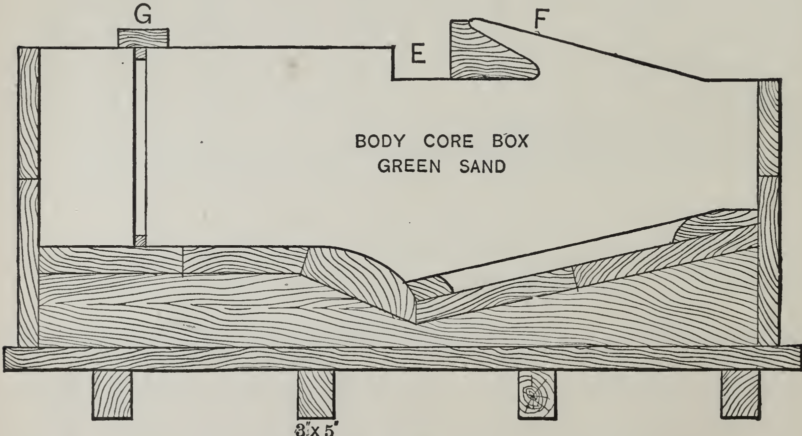


Fig. 136.

full length of the opening between the wings on the front of the casting. A section of this core-box is shown at Fig. 135. As will be seen by the drawing, it is open on the top, and the pieces for forming the recesses for the wedges set in each end, as shown at *D*.

Some moulders would prefer to have these pieces made loose, and set in the top of the box, as it would save the trouble of turning the core over before setting it in the mould.

When this core is set in position, the green-sand core rests upon it. In many cases, however, this core is not required, as the green-sand core runs clean through, and two small dry-sand cores are put in at the sides to form the recesses for the wedges, and projecting over far enough to balance.

A section of the body core-box is shown at Fig. 136. This box should have a good solid foundation. As represented in the drawing, it is made as follows: —

First, get out four pieces of scantling $3'' \times 5''$, and plane them square and true on one edge. When this has been done, get four or five pieces of $2''$ plank, and screw them fast to the $3'' \times 5''$ scantlings; on this foundation build the bottom of the box, as shown in the figure. The sides and ends must be made loose, and held in place by four $\frac{5}{8}''$ bolts.

When the core has been made, these bolts can be drawn out, and the sides and ends of the box taken away separately. This leaves the core standing on the bottom of the box, from which it can be lifted without danger of breaking.

The loose piece shown at *E* runs across the top of the box, and is used in order to keep the point *F* from breaking off. The piece shown at *G* is also loose, and is the full length of the box; it is put on for the purpose of holding the piece which forms the small flange on the inside of the casting.

A plan of the cast-iron frame used for the purpose of supporting the green-sand body-core is shown at

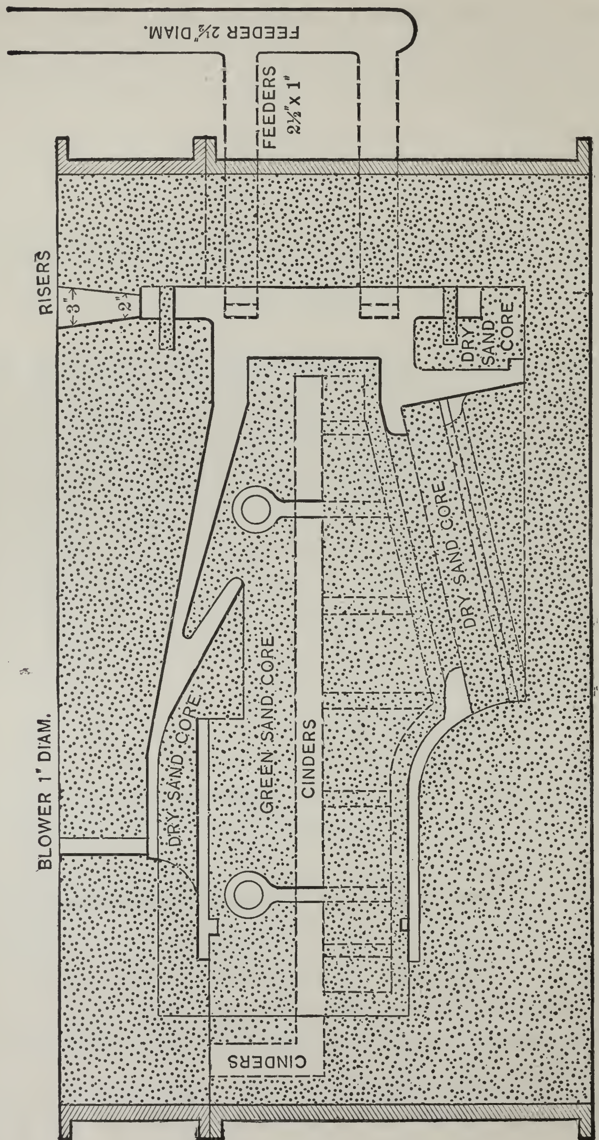

FEEDER 2½" DIAM.
FEEDERS 2½" x 1"
RISERS
3"
2"
DRY SAND CORE
DRY SAND CORE
GREEN SAND CORE
CINDERS
DRY SAND CORE
BLOWER 1" DIAM.
CINDERS

Fig. 137.

Fig. 139. This frame should have two $1\frac{1}{2}''$ eye-bolts (fastened securely in the position shown by dotted lines, Fig. 137) to lift it by.

When this frame has been placed in the core-box and rammed up level, the core should be well vented down-

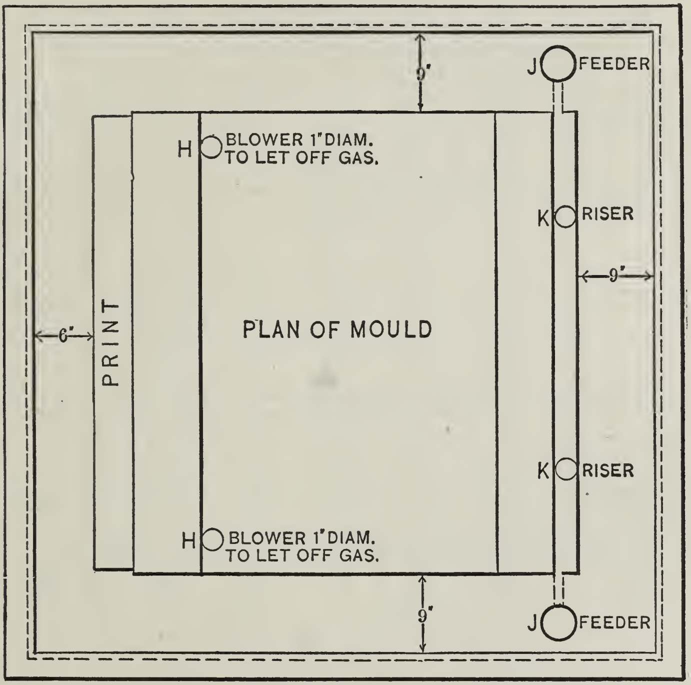
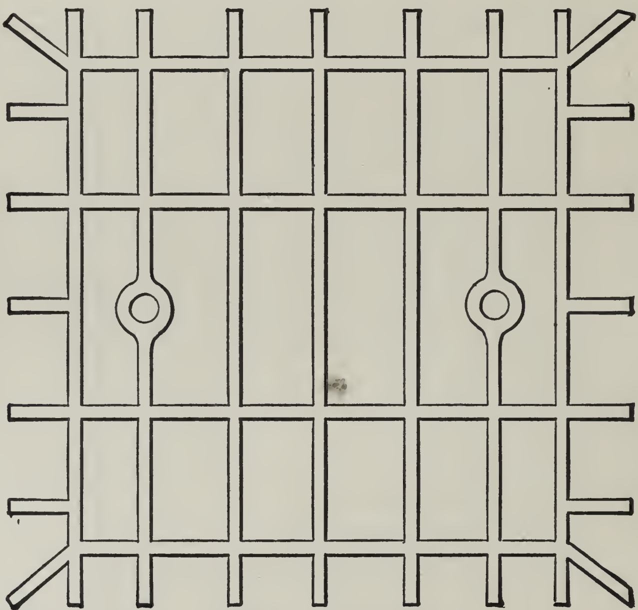


Fig. 138.

wards, and then a layer of cinders, $1\frac{1}{2}''$ thick, laid on, and continued through the print, and up between the end of the print and the side of the flask, as shown in Fig. 137. This will carry away all the gas; and the cinders and green-sand will allow the mortar to contract when cooling, and thus avoid the danger of breaking the casting.

The method of casting the mortar is shown at Figs. 137 and 138, and requires very little explanation. As will be seen by the drawing, it is moulded in an iron flask. Two blowers 1″ in diameter, to let off the gas, are shown at *H H*, Fig. 138. The main feeders *J J*



PLAN OF CORE IRON

Fig. 139.

should be $2\frac{1}{2}''$ in diameter, and from each of these make two branch feeders $2\frac{1}{2}'' \times 1''$. The risers *K K* are 3″ in diameter at the top, and taper down to 2″ at the bottom. These may be fed with hand ladles, and pumped in with a rod till the metal sets.

CHAPTER XXI.

MOULDING LARGE HOLLOW CASTINGS IN DRY-SAND.

Fig. 140 is a general drawing of a hopper for Walker's Patent Sulphurizing Furnace; and it will

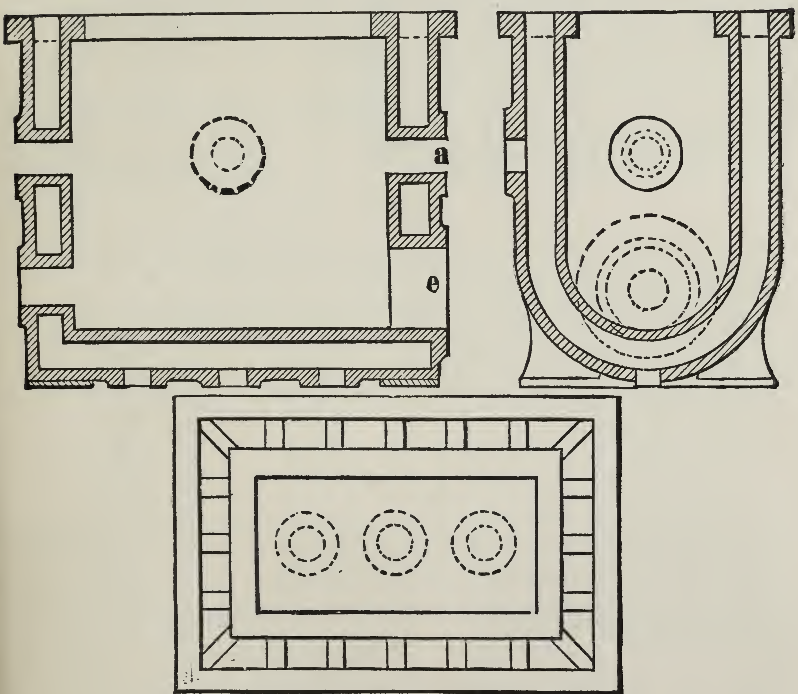


Fig. 140.

serve as a good illustration for this subject, viz., moulding in dry-sand.

A side and end elevation of the pattern is shown at Fig. 141. The body of the pattern has four strong draw-irons as shown at *B;* and the feet *A* and all the

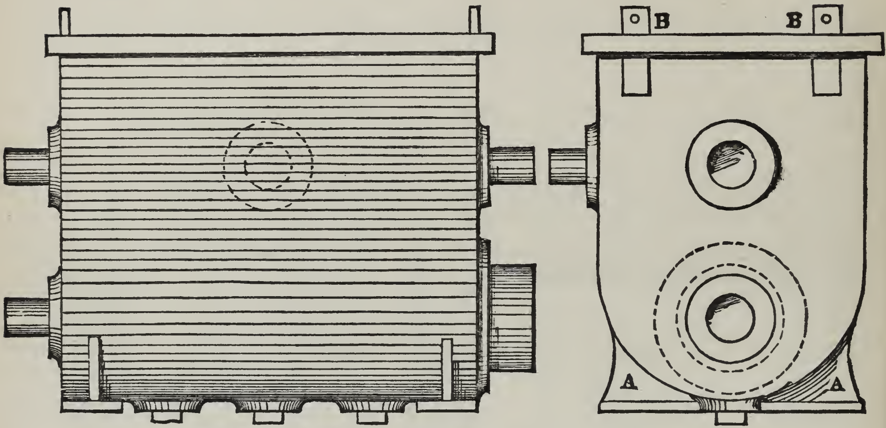


Fig. 141.

facing pieces and points are loose, and held in position by screws and dowels.

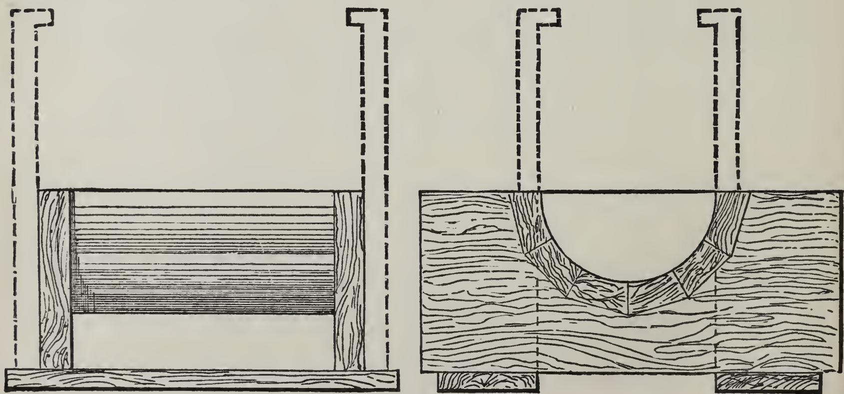


Fig. 142.

Fig. 142 and 143 are the different side and end sec-

tions and elevations of the centre, or body core-box. It is seen by the drawing, that the ends are made

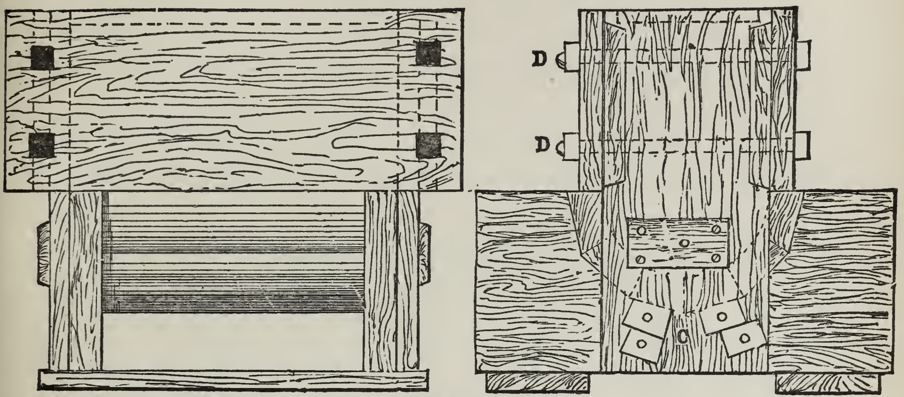


Fig. 143.

loose, and held in place by the screws *C* and the four $\frac{5}{8}''$ bolts shown at *D*.

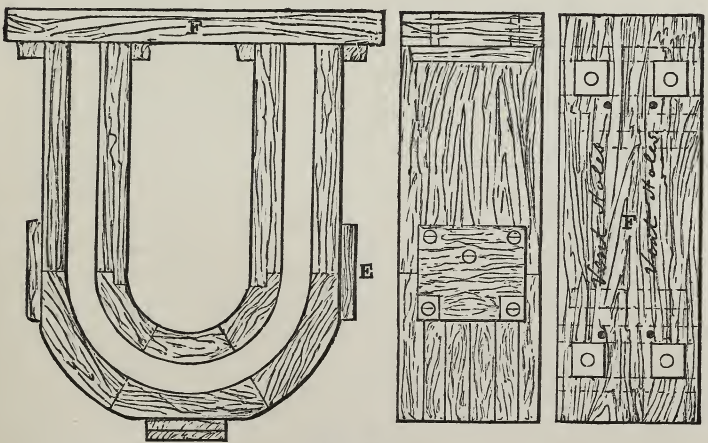


Fig. 144

When the core is made, and ready to lift from the

box, the four bolts can be taken out, and the sides removed. When this has been done the screws *C* may be taken out, and the ends lifted away. This leaves the core standing in the bottom section of the box shown at Fig. 142, from which the core can be lifted without the slightest danger of breaking.

The jacket-core for the sides of the casting are to be made in three sections. The plan, side and end eleva-

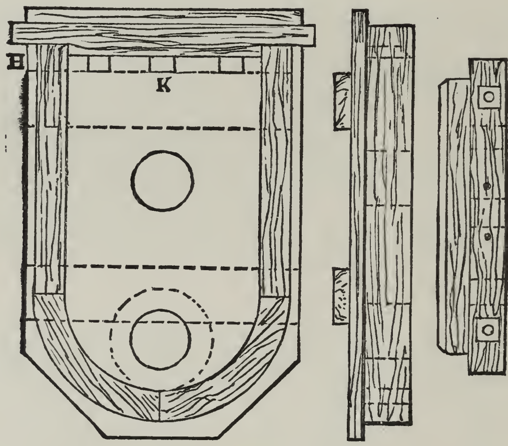


Fig. 145.

tions of the box are shown at Fig. 144. By referring to the drawing, it will be seen that the box is made open at the top and bottom, and parted at both sides at *E*, and also at the end *F*, all the different sections being held in place by screws. The square end of the box should have four $\frac{7}{8}''$ vent-holes bored, as shown at *G*. When making the core, the box should be set upon the dry-plate upon which the core is intended to be baked. Then, when the core is made and ready to draw, the screws which hold the box together at *E* and *F* can

be taken out, and the different sections of the box removed without disturbing the core, when the dry-plate and core can be lifted and placed in the oven to dry.

Fig. 145 is the plan, side and end elevations of the jacket core-box for the ends of the casting. It is a plain box open on the top; and the hubs for forming the wall around the opening *e a*, Fig. 140, are loose;

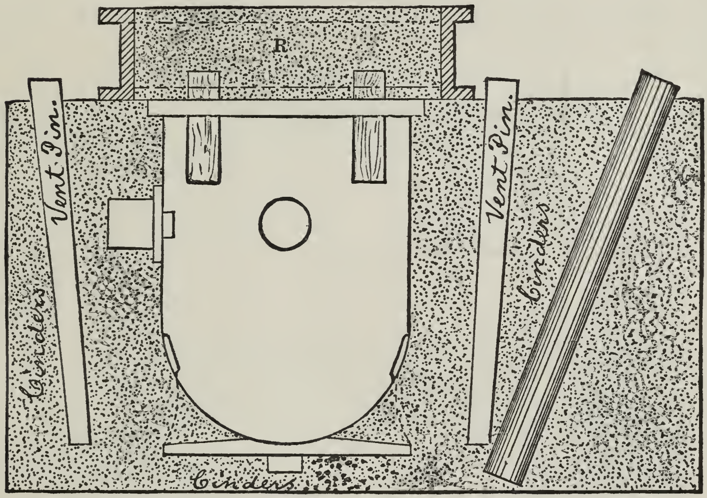


Fig. 146.

the square end is also loose at *H*, and has two $\frac{7}{8}''$ vent-holes bored between the bridges *K*. When the core is ready to take out of the box, it should be covered with a dry-plate, and turned over. After this has been done, take the screws out at *H*, and draw the square end and bridges *K;* then lift off the body of the box, and draw the hubs *a e;* finish the core, and it is ready for the oven.

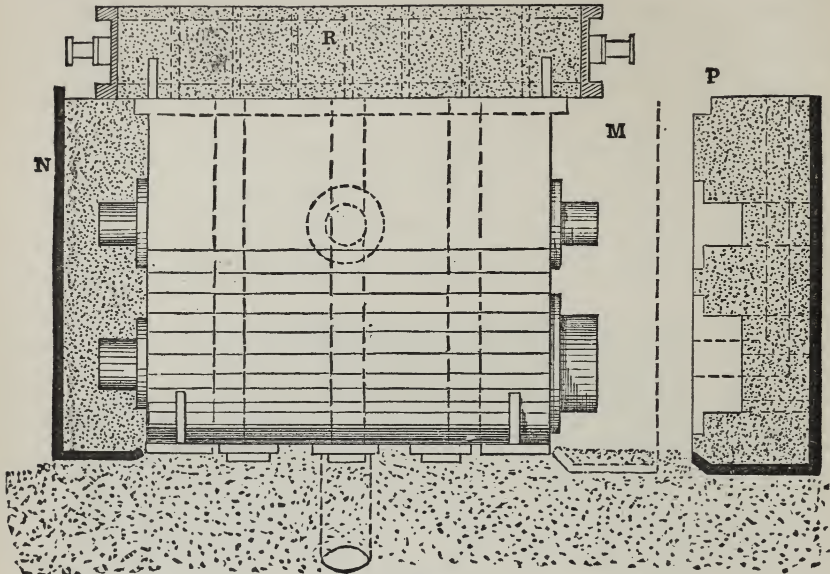


Fig. 147.

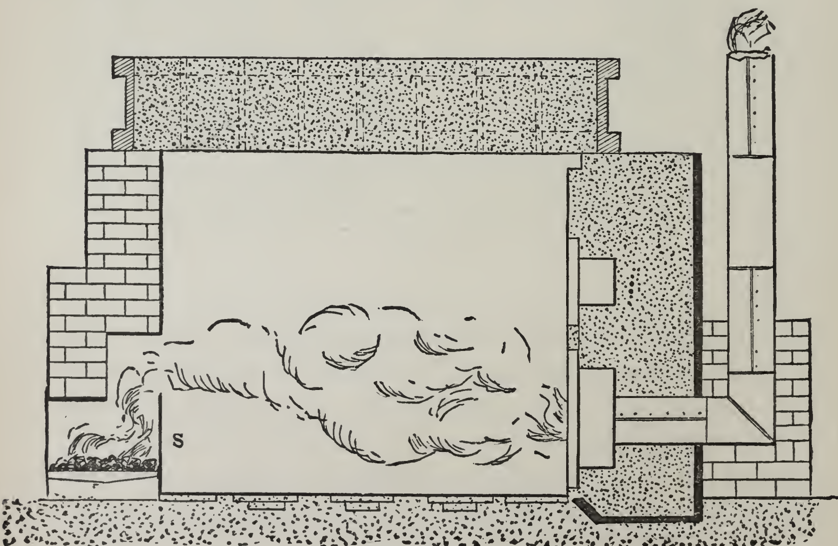


Fig. 148.

MOULDING.

Fig. 146 is an end view of the mould, showing the pattern, gas vent-pipe, and steam-vents. When the proper excavation has been made in the floor, the bottom must be covered with a layer of cinders, about 6″ thick, and then 5″ or 6″ of sand, and upon this make the bed for the bottom of the pattern. This part of the mould should be well vented downwards to the cinders, which will take away all the gas from the bottom of the mould by way of the 4″ pipe shown in the figure.

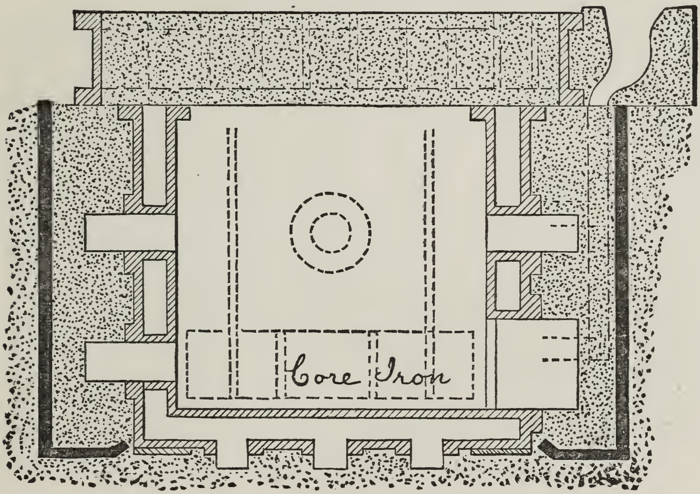


Fig. 149.

When the pattern has been set in position, and is ready to mould, set three $2\frac{1}{2}''$ vent pins at each side as shown. Fill in and ram up the sides square with the ends and level with the top of the pattern, leaving an opening of about two feet at each end. Cast-iron draw-back plates may then be set in the position shown by dotted lines *M*, Fig. 147, and rammed up as shown at

N, making the two $1\frac{1}{2}''$ feed-gates shown at *P*. The cope flask *R R*, Figs. 146 and 147, may then be put on and rammed up, using $\frac{3}{4}''$ gas-pipe for venting the body and jacket-cores. When the cope has been rammed up, it may be lifted off, and the ends of the mould drawn back to the position shown at *M P;* and, as one end has to be dried in the core oven, it may be lifted right

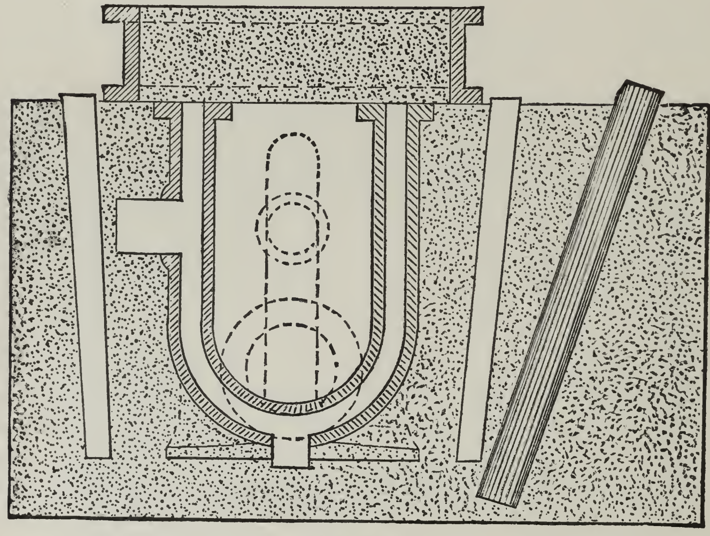


Fig. 150.

out of the mould, finished, and put in the oven at once. Having taken off the cope and ends of the mould as stated, the body of the pattern can be drawn from the sand, and the feet and facing pieces which will remain in the mould can then be drawn in towards the centre.

The method of drying the mould is shown at Fig. 148.

Having set the end *M P* and the cope back in place, build the temporary fire-box *S*, and kindle the

fire; the heat will dry the mould as it passes back from the fire to the smoke-flue shown in the figure.

When the mould has been dried and finished, the cores set, and the mould closed, as shown at Figs. 149 and 150, it is ready to cast.

CHAPTER XXII.

THE SCREW-PROPELLER: HOW TO MAKE IT.

In order to lay out a screw-propeller, we must first ascertain the following dimensions: the kind of screw required, the extreme diameter, the number of blades, the thickness of the same, the width of the blade measured along a tangent at the extreme diameter, and the size and form of the hub.

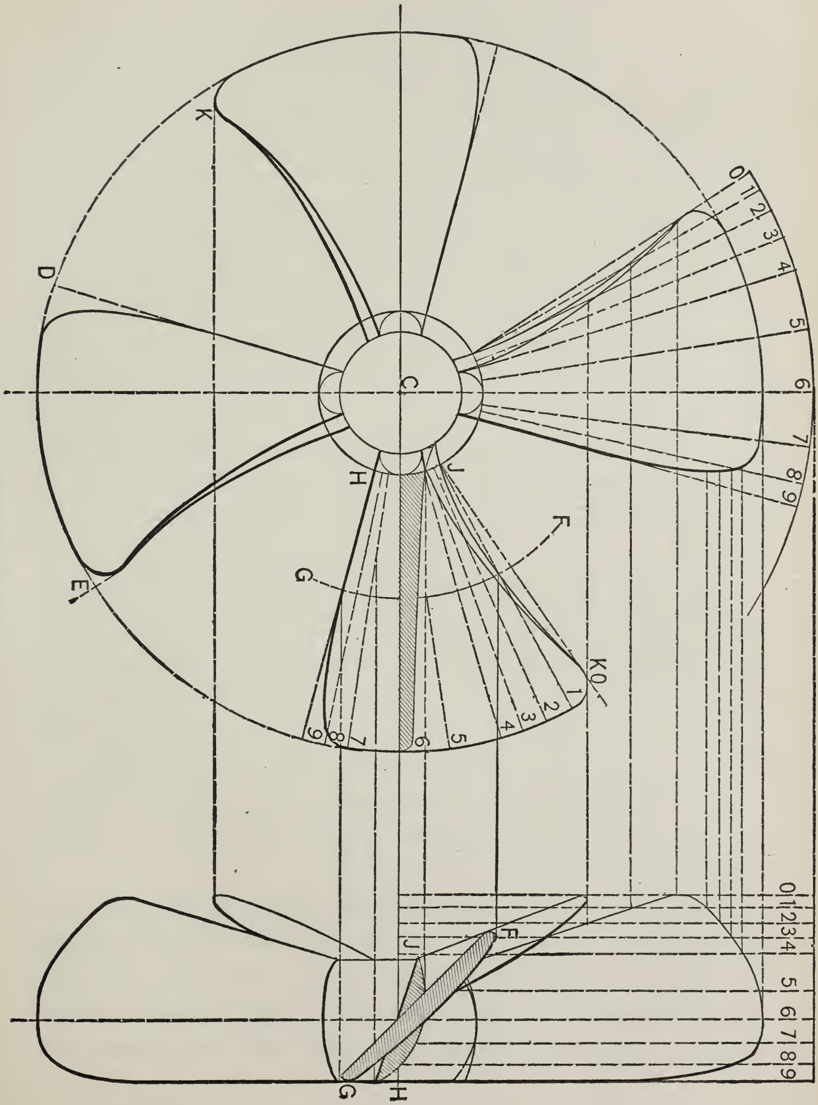
In this article I will illustrate a good method of drawing, pattern-making, and moulding a true screw; in other words, a screw in which every equal portion of a revolution of the generatrix corresponds to an equal advance along the axis. This method (with slight variations) may be adopted for the construction of the different kinds of screw-propellers in general use.

DRAWING.

A method of laying out a screw-propeller is shown at Figs. 151, 152, and 153. Fig. 151 is an end view, and Fig. 152 is a side view; Fig. 153 shows the mode of determining the development of the thread or angle of the blade. The angle of the blade is as the pitch of the screw to the circumference of the same.

Example: Circumference of screw, 54′. Pitch of same screw, 24′. Angle of blade, 24′ to 54′; which

being reduced to a lower term is equal to an angle of 12″ to 27″, as shown at Fig. 153.



Figs. 151 and 152.

To determine the pitch of the screw developed on a tangent plane, draw a vertical line through the points *A B*, Fig. 153, and set off on it (to a convenient scale) the length of the circumference of a circle, the radius of which is equal to half the diameter of the screw-propeller required. At this point draw the line *B C*, equal to the pitch of the screw. If we now draw a line through the points *A C*, it will represent the development of the thread, or angle of the blade on a tangent plane.

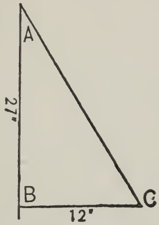


Fig. 153.

We now take *C*, Fig. 151, as a centre, and describe the circle representing the end view of the propeller required. On this circle lay off the points *D E*, which we will assume represent an end view of the blade before the corners have been rounded off. Between the points *D E* lay off the aliquot parts 0, 2, 4, 5, 6, 7, 9, and if necessary 1, 3, 8, and draw radii from these points.

Now take 6 for a centre in the side view, Fig. 152, and lay off on each side of it the aliquot parts 7, 8, 9, 5, 4, 3, 2, 1, 0, points to the pitch corresponding to the same parts of the circle in Fig. 151. If from the points of the circle 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, in the end view, we draw the dotted lines joining the corresponding points in Fig. 152, the points so joined will of course represent the generating points, or outline of the blade in the side view.

Now, if the lines drawn from the points 0, 1, 2, 9, etc., in the end view, and joining the corresponding numbers in Fig. 152, give the various points for the outline of the blade in the side view, it of course follows that by nearly the same method of procedure we can

develop a sectional or end view of any given point of the blade, as *F*, *G*, *H*, *J*, or *K*.

PATTERN-MAKING.

When a screw propeller is to be cast in loam, as in the present case, it is sometimes well to make a complete pattern of the hub: but for large sizes it is generally built up in loam; and, when such is the case, it will be necessary to make a sweep-board, or templet, to guide the moulder in his operations. Such a templet is too simple to require any description or illustration. When a complete pattern of the hub is made, it must have a hole through the centre just large enough to be an easy fit on the spindle which the moulder uses when working on the job in the foundry.

The principal work of the pattern-maker, however, consists in making the sweep-boards and curved guide-boards, which are necessary to the moulders in producing the correct form of the blade.

Since the acting surface of the blade is made up of straight-line elements, or, as stated in the commencement of this article, every equal portion of a revolution of the generatrix corresponds to an equal advance along the axis, it is evident that the same surface can be produced in loam by moving a straight-edged sweep-board along a guide-board having an acting surface which corresponds to the extreme helix of the blade. Such a straight-edged sweep-board is shown at *L*, Fig. 157, and needs no further explanation. Fig. 155 represents the curved sweep-board for forming the back of the blade.

The curved guide-board for the outer helix of the blade is shown at Fig. 156. The method of projecting

the curved or working surface of this board is shown at Fig. 154, and is as follows: —

Draw the horizontal line *M N*. Let *M* represent the centre of the hub, or the element *C*, Fig. 151; and with a radius equal to half the extreme diameter of the propeller, describe the arc *O P*. This will represent the element *D E*, Fig. 151, or, in other words, the actual limit of the blade. As the moulder will have to build a good margin of brickwork outside of the blade, we must take a radius of about 8″ or 10″ additional length,

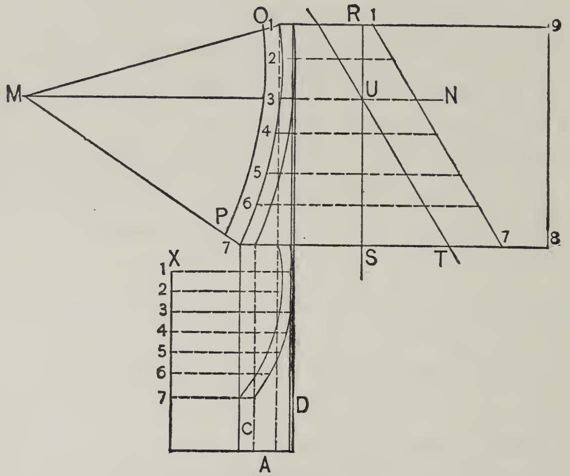


Fig. 154.

and draw the arc 1 7. This will represent the inside corner of the acting surface of the guide-curve. We can now add the desired thickness of the guide-curve to the radius, and strike the arc representing the outside corner of the same. Set off, on the arc representing the inside corner of the curve, a number of aliquot parts, as 1, 2, 3, 4, 5, 6, 7. Let *M*, 3, 1, 7, represent

the elements *C*, 6, 0, 9, Fig. 151. Now draw the vertical line *R S;* and at *S* draw the horizontal line *S T*, equal to the pitch (or the corresponding part of it); and from *T* draw the line cutting through the point *U:* this represents the developed helix. If we now draw the line 1 7 parallel to *T U*, and the horizontal lines 7 8 and 1 9, join 8 and 9, as shown in the figure, we produce a complete side view of the guide-curve.

The point to which we now direct our attention is to project the end view. For this purpose we draw the vertical line *X*, equal to 1 9, and from the base line *A*, at a distance equal to 7 8, make the point 7, and on the remainder set off a number of aliquot parts corresponding in number to 1, 2, 3, 4, 5, 6, 7. From the points draw the horizontal dotted lines, and from the corresponding points of the arc 1 7 drop perpendiculars. Through the various points of intersection, draw the curved lines representing the top edge of the guide-curve.


Fig. 155.


Fig. 156.

If we now draw the horizontal line *A*, and the vertical lines *C D*, we have a complete drawing of the guide-curve required.

It only remains for us to build up — either with staves or segments — a block of wood large enough for the purpose. Work it out to the proper shape, and we are ready for

MOULDING.

The method of moulding is shown at Figs. 157, 158, and 159, and is as follows: —

In starting, the moulder first sets the step and spin-

dle *NT*, Fig. 157, and then adjusts the spindle-arm *O*, to which he then bolts a straight strickle-board, and, with this, sweeps off a good level bed for the mould. He then removes the straight strickle-board from the

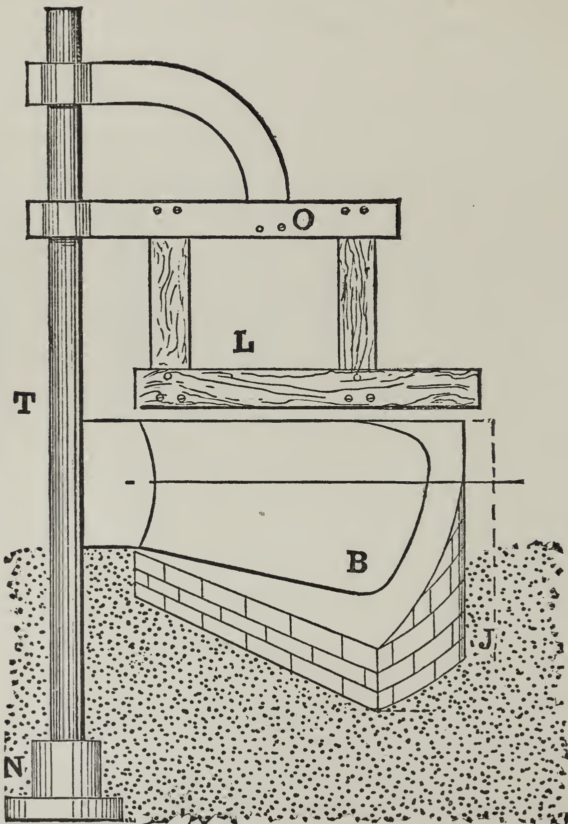


Fig. 157.

arm *O*, and in its place adjusts the one marked *L*, and shown in the figure.

The curved sweep-board for the back of the blade,

shown at Fig. 155, is then screwed to *L*, letting it project below the bottom edge just the thickness of the required metal in the blade.

We will now take the curved guide-board, shown at Fig. 156, and set it in the position indicated by the dotted lines, and proceed to mould up the back of the

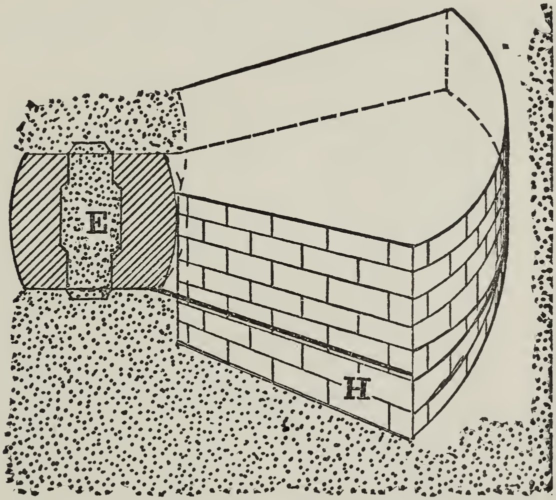


Fig. 158.

blade by building up the form of brick. This should be well bound together with iron rods, bolts, cement, and sand, as shown at *J*, Fig. 157.

We can now spread the loam over this rough form of brick, and work it to the required shape by rotating the curved sweep-board (which has been adjusted for this purpose) around the spindle *T*. Then take off the curved sweep-board, and swing the arm *O* and sweep-board *L* around out of the way. Round off the corners, as shown at *B*, and, in fact, finish the mould by hand, and then let it dry.

After drying, the form of the blade is filled up with sand, and then swept off true with the straight sweep-board *L*, thus producing the acting surface of the blade.

Then we are ready to remove the curved guide-board, make parting, and then cover the whole surface with loam, and upon this loam build the cope, as shown at *H*, Fig. 158. While building the cope, great care should be taken to have it well vented, and a riser or flow-off set, as shown at *R*, Fig. 159.

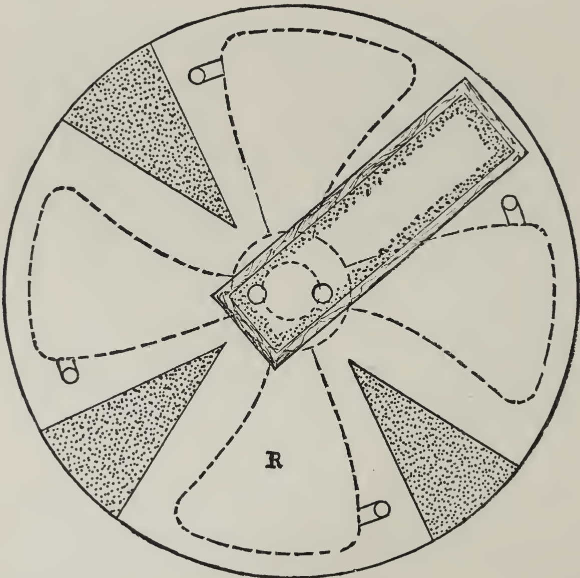


Fig. 159.

Remove the sand from the form of the blade after the cope has been lifted off.

The blades are thus moulded separately; and when each section has been thoroughly dried and finished, we are ready to close the mould, set the hub-core *E*, Fig. 158, make the joints tight and secure, and be tolerably sure of turning out a good casting.

CHAPTER XXIII.

ENGLISH AND AMERICAN CUPOLA-PRACTICE. — STEWART'S PATENT RAPID CUPOLA.

It seems strange that so little has been done of late years to improve upon the somewhat crude and ineffective arrangements which have so long constituted the "best practice" in the engineering of iron foundries.

Engineers seem too frequently to have allowed the iron foundry pretty much to look after itself. Given a good pattern-shop, a well-equipped machine-shop, and an appropriately arranged erecting-shop, it was seemingly considered sufficient if the foundry was provided with a moderately good cupola of the old school, and ample crane arrangements.

A new departure in cupola-practice, and in the engineering of foundries, which has recently taken place on both sides of the Atlantic, is, therefore, a matter of some interest and congratulation.

Before presenting to the reader these two representative — English and American — cupolas, I wish to express my most cordial thanks to the eminent engineers, Messrs. Alexander Stewart and Victor Colliau, who have kindly furnished me with drawings and particulars of their inventions, together with other valuable information.

Neither of these gentlemen claims that the entire

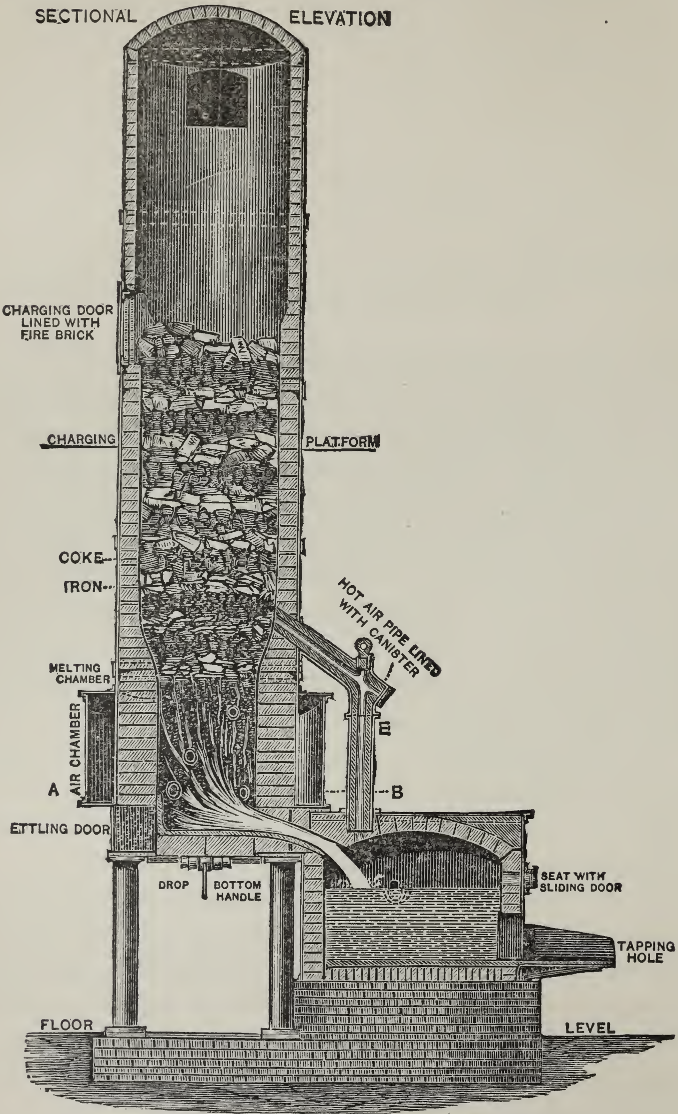

SECTIONAL
ELEVATION
CHARGING DOOR LINED WITH FIRE BRICK
CHARGING
PLATFORM
COKE
IRON
MELTING CHAMBER
AIR CHAMBER
A
B
E
HOT AIR PIPE LINED WITH CANISTER
ETTLING DOOR
DROP
BOTTOM HANDLE
SEAT WITH SLIDING DOOR
TAPPING HOLE
FLOOR
LEVEL

Fig. 160.

features set forth in their inventions are new; but with a knowledge of the various forms of melting used in England, the United States, and other countries, combined with their own experience gained from constructing cupolas, they have, after many experiments, placed before iron-founders cupolas possessing the double merit of rapid melting in connection with a comparatively low consumption of fuel.

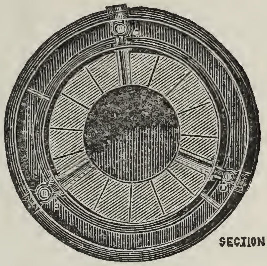


Fig. 161.

From a glance at the accompanying illustrations, both methods will be readily understood.

The main feature of Stewart's patent rapid cupola lies in having its internal diameter reduced at the melting part.

There are also several tuyeres arranged in three zones, termed the lower, middle, and upper zones, and respectively indicated in Fig. 163 by the letters *A B C.* In the top row, *C*, each tuyere is provided with a shut-off valve. These three valves have their plugs connected with a malleable-iron pitch chain, and are opened or shut simultaneously, each to an equal extent, with the one handle.

All of the three rows of tuyeres are placed in communication with one another by means of an annular casing or air-belt. On each side of this air-belt is secured a cast-iron quarter-bend blast pipe *A*, Fig. 162, and to each bend is connected a turned shut-off valve *B*. Upon the air-belt is fixed a blast-pressure gauge *D*, to indicate the pressure of air in the cupola. The pipe *E*, Fig. 160, conveys the hot blast from the receiver back to the cupola furnace. All the tuyeres are fastened to the shell

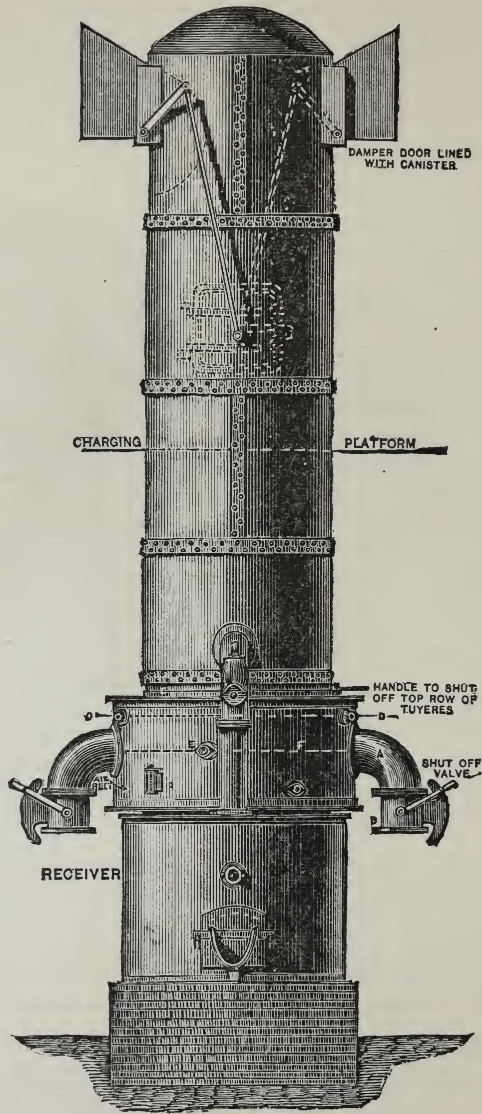

DAMPER DOOR LINED WITH CANISTER
CHARGING
PLATFORM
HANDLE TO SHUT OFF TOP ROW OF TUYERES
D
D
E
A
SHUT OFF VALVE
RECEIVER

Fig. 162.

with bolts and an asbestos ring; and opposite each tuyere is provided a circular cover, which moves off and on, and when on is perfectly air-tight. These circular covers are provided with mica disks; and the respective areas of the three rows of tuyeres have been proportioned by experiment to give the most effective distribution of blast and of economical results. The cupola is arched over at the top, as shown in the illustration, but has an

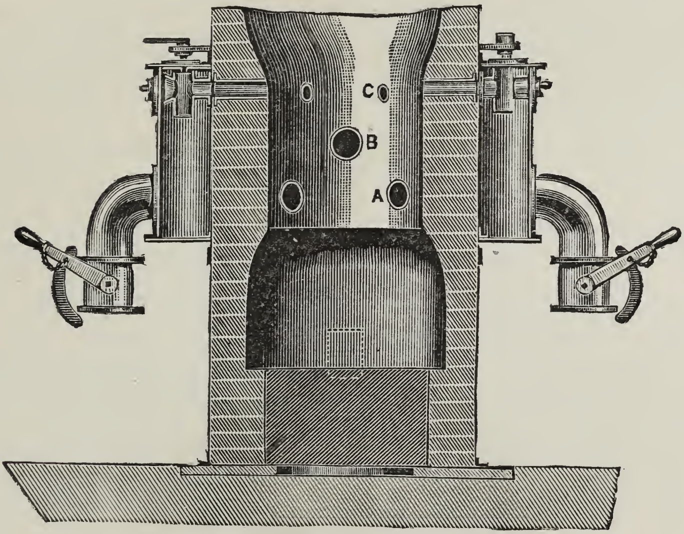


Fig. 163.

Stewart's Patent Rapid Cupola: View of Lower Portion of Cupola enlarged to form Receiver.

opening (shown in Fig. 162), fitted with a flap-door for the escape of the gases involved from the combustion of the coke. This arrangement is a most important one; as it entirely obviates the danger and nuisance of sparks and cinders blowing out upon the neighboring property, which, when containing inflammable material,

is often placed in no little jeopardy where the old system is in vogue. The flap-door can be set at any angle; and consequently the sparks, etc., which are usually ejected in considerable quantities during blowing-off operations, may be deflected in any direction, or to the ground at the base of the cupola. The cupola is erected upon a cast-iron plate, which rests on four pillars. It is also provided with a drop bottom. The fixed receiver stands immediately in front of the cupola. It is constructed with a spout, and is of large enough proportions to contain the maximum quantity of melted iron that may be required from the cupola.

When the fixed receiver is used, the molten metal may be run direct from it into the ladles, which may then be transported, by means of crane attachments, to the moulds. When the fixed receiver is employed, therefore, no alteration in the pre-existing state of affairs in the moulding-shop need be made.

But there is still another form of receiver which really forms part of the cupola itself, and consists essentially of an enlargement of the base, as illustrated in Fig. 163. In this case, which more nearly resembles the ordinary cupola, the arrangement of tuyeres, air-belt, valves, and other accessories, is the same as when an external fixed receiver is employed. The ejector valve, however, is not required, and the base of the cupola is fixed to a cast-iron base plate. Our engraving, Fig. 163, shows the cupola with the upper portion left off from the first joint above the air-belt.

The cupola illustrated is one of the four-tons melting capacity per hour; but Stewart's cupolas can be made of any capacity from one to twenty tons per hour. The one illustrated requires a bed of about four hundred-

weight of coke, whereas ordinary furnaces take usually about thirteen hundred-weight. There is here, then, an initial saving of nine hundred-weight of coke. The approximate dimensions of a four-ton cupola, on Stewart's system, are as follows: External diameter of shell, 4′; total height from ground line, 24′; height from ground line to under side of air-belt, 5′; depth of air-belt, 2′ 6″; diameter of air-belt, 5′ 6″; melting part of cupola, 3′ 6″ deep by 1′ 10″ diameter, widening to an internal diameter of 3′ in upper portion of cupola; thickness of lining at melting part, 1′ 1″; upper portion, 4½″; internal diameter of receiver, 3′ by 3′ deep; and height of tapping hole from ground line, 2′ 3″.

A number of important advantages are claimed for this new cupola, and iron-founders will readily recognize their practical utility.

First of all, in keeping with its name, the melting takes place rapidly and with great uniformity. Thus more rapid melting can be effected, and that, as we have already pointed out, with a great reduction in the amount of fuel consumed. Further, there is an absence of flame at the top of the cupola, which remains comparatively cool throughout, — a state of affairs obviously calculated to conduce to durability. No combustible gases are discharged, carbonic-acid gas alone escaping; and the additional fuel thus obtained enables the smaller quantity of coke to suffice.

At a test made at Messrs. Rushforth & Co.'s, St. James's Foundry, Bradford, England, the results were highly satisfactory; the rapidity with which the metal was run down being astonishing. The consumption of coke also, one hundred-weight to fourteen hundred-weight of iron, was much lower than is requisite with

the ordinary cupola; it being generally the practice to allow one-seventh the weight of the iron for fuel. This has, however, been improved by a subsequent test, a proportion of one hundred-weight of coke to eighteen hundred-weight of iron having been found sufficient.

The following is a result of a test made March 8, 1884:—

CUPOLA 4′ DIAMETER; LENGTH OF SHELL, 19′.

	Time.
Time of lighting fire	10.00 A.M.
Put in coke for bed of cupola . . .	10.30 "
Making up of door .	11.00 "
Commenced charging	11.05 "
Filled up cupola .	12.30 P.M.
Commenced blasting	1.05 "
Metal running down	1.15 "
Took away first metal in 35 minutes after blasting	1.40 "
Second metal taken	2.15 "
Third metal taken .	2.30 "
Fourth metal taken	2.35 "
Finished charging .	2.15 "
Finished blasting .	2.35 "

Charge of Coke in pounds.	Charge of Iron in pounds.
Bed, 336	1,792
" 112	2,016
" 112	2,016
" 112	2,016
" 112	2,016
" 112	2,016
" 112	2,016
" 112	2,016
" 112	2,016
1,232	17,920

Speed of Blower in revolutions.	Pressure of water in inches.	Time when taken.
425	37	1.10
430	32	1.40
425	29	2.15

Fuel used for bed, coke	336 pounds.
Fuel used for fusion, coke . . .	896 "
Total consumption of fuel . .	1,232 pounds.
Amount of iron melted in cupola .	17,920 pounds.

REMARKS.

This was a melting of eight tons of iron with 1,232 pounds of coke, in one hour and a half from starting to finishing blasting. The time taken to melt the iron, after having taken away the first ladleful of metal from receiver to taking away last metal, was only 55 minutes.

Note.—14.54 pounds of iron to 1 pound of coke.

Note.—Coke used, exclusive of bed, 896 pounds, and amount of iron melted, 17,920 pounds; or 1 cwt. of coke per ton of iron.

Another test was made at Messrs. Haxby, Sewell, & Fleming's, Well Lane Foundry, Halifax, with a

No. 5 CUPOLA, 4′ 6″ DIAMETER; SHELL, 16′ 3″.

	Time.	Charge of Coke in pounds.	Charge of Iron in pounds.	Speed of Blower in revolutions.	Pressure of water in inches.	Time when taken.
Time of lighting fire	10.45 A.M.	Bed, 504	1,866.6	370	21	1.00
Put in coke for bed		" 112	1,866.6	410	21	1.55
of cupola . . .	11.15 "	" 112	1,866.6	416	25	2.45
Making up of door .	12.30 "	" 112	1,866.6			
Commenced char-		" 112	1,866.6			
ging	11.30 "	" 112	1,866.6			
Filled up cupola .	12.30 "	" 112	1,866.6			
Commenced blast-		" 112	1,866.6			
ing	12.55 "	" 112	1,866.6			
Metal running into		" 112	1,866.6			
ladle	1.10 P.M.	" 112	1,866.6			
Made up tapping-		" 112	1,866.6			
hole of receiver .	1.10 "	" 112	1,866.6			
Took away first metal in 30 minutes after blasting	1.40 "	1,736	22,399.2			
Second metal taken	2.10 "					
Third metal taken .	2.30 "					
Fourth metal taken	2.55 "					
Finished charging .	2.25 "					
Finished blasting .	2.55 "					

Fuel used for bed, coke	504 pounds.	
Fuel used for fusion, coke . . .	1,232	"
Total consumption of coke . .	1,736 pounds.	
Amount of iron melted in cupola .	22,399 pounds.	

REMARKS.

The fire had not burned up, and was very dull at starting of the blast. The quality of coke was not the best. Each charge of metal consisted of about 1,344 pounds of pig and 522 pounds of good scrap-iron, broken from lathe-bed castings, etc.

Ten tons of iron were melted with 1,736 pounds of coke in two hours' time from starting to finishing blasting. The time taken to melt the iron, after having taken away the first ladleful of metal from receiver to taking away last metal, was only one hour and a quarter.

Note.—12.326 pounds of iron to 1 pound of coke.

Note.—Coke used, exclusive of bed, 1,232 pounds, and amount of iron melted, 22,399.2 pounds; or 1 cwt. of coke per 18.181 cwt. of iron.

THE COLLIAU CUPOLA.

Many of the advantages claimed in favor of the rapid cupola are also applicable to the Colliau cupola shown

in sectional elevation at Fig. 164, and in perspective elevation at Fig. 165. *D*, Fig. 164, represents the air-box, *G G* the lower tuyeres, *F F* the upper tuyeres; *E* is the arch over the tap-hole *L*. E^1 is the arch over the slag-hole *H*. The line from *F* to *J* shows the inclination of the upper tuyeres *F F*. *K* is the inside brick

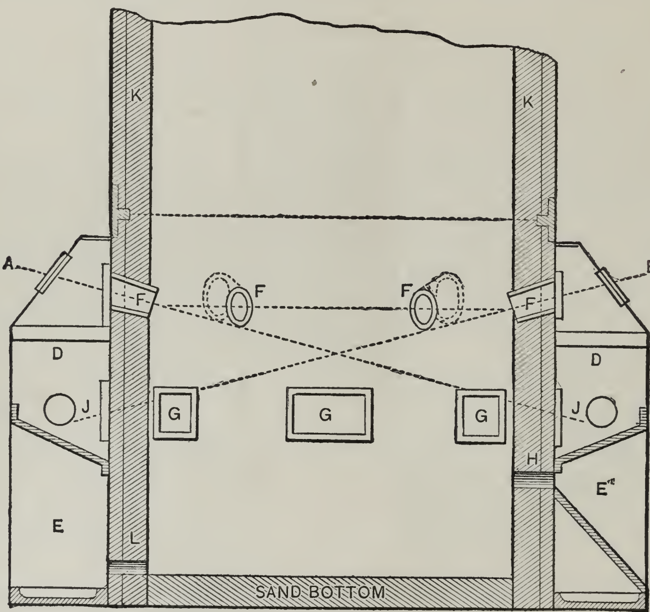


Fig. 164.

Sectional Elevation of the Colliau Cupola.

lining. The peculiar features of the Colliau cupola are the proportions and arrangements of the upper and lower tuyeres. The lower tuyeres are rectangular, and are intended to furnish the air necessary to the combustion of the fuel.

They are generally open during the fusion, but as they have gates inside of the air-box, they can be shut more

or less during the working to direct the blast more on one side than the other if necessary, or may be shut

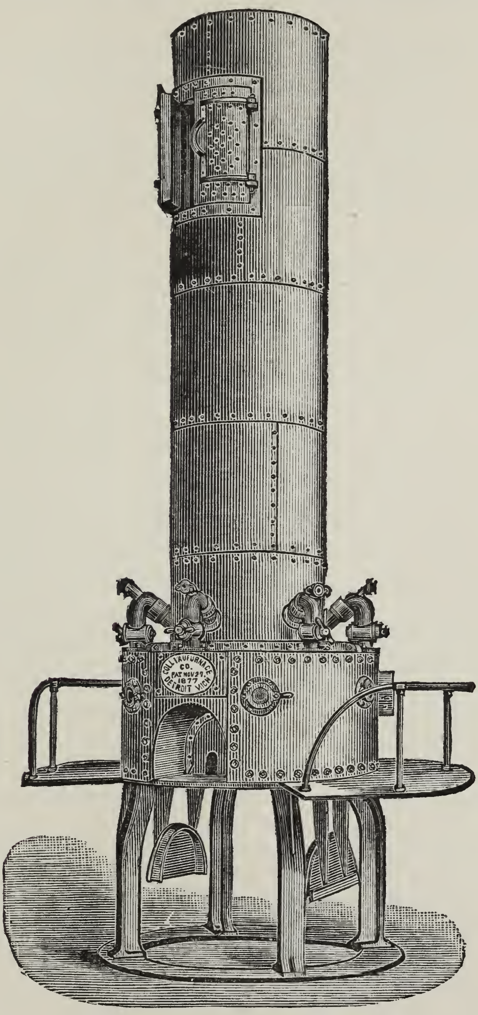


Fig. 165.

altogether (in case of accident to the blower, for instance.)

The upper tuyeres are round, and point downwards. They are arranged to alternate with the lower tuyeres. Their inclination is proportionate to the diameter of the cupola in such manner that the blast from them will reach the focus of combustion produced by the lower tuyeres. They are closed when the blast is turned on, and opened when the iron shows at the tap-hole, and the cupola is plugged up to accumulate the first draught of iron.

This is accomplished by moving the lever handle, which is shown on the top of the air-box. The opening of these tuyeres produces a downward blast of air (on the principle of a blow-pipe), and furnishes the oxygen necessary to the combustion of the hydro-carbon gas, which, without it, would be thrown off by the imperfect combustion of the fuel at the level of the lower tuyeres. This combined blast produces a melting point about 18″ above the upper tuyeres, and *nowhere else*, concentrating the heat in the smallest possible compass, so that the metal in fusion has less space to traverse while exposed to the oxidizing influence of the blast, thereby insuring tougher castings, and also perfect combustion of the inflammable gases (with corresponding economy of fuel), contrary to the usual practice of spreading the blast as much as possible. In the practical use of this cupola, there is no flame at the loading doors, and no turning-off of combustible gases at the top of the stack — carbonic-acid gas alone escaping (which is the product of perfect combustion). Meltings of ten to twelve pounds of iron, with one pound of fuel, are obtained in this cupola, according to the quantity of metal melted at a heat. Another point is the rapidity of melting, which increases as the operation is carried on instead

of decreasing, and also in giving hotter iron at the end than at the beginning. This is the reverse of *all* other cupolas.

The following is the result of a test made at the works of the Detroit Car-wheel Company:—

Certificate of quantities of Fuel used and Iron melted at the Foundry of the Detroit Car-wheel Company.

Fuel used for bed, coke	1,500 lbs.
Fuel used for fusion	6,900 "
Total consumption of fuel	8,400 "
Amount of iron melted in the cupola . . .	94,000 "

Lighting . .	10 o'clock.	10 tons loaded at .	11.30 o'clock.
		20 " " .	12.45 "
Loading commenced	——	30 " " .	1.55 "
		40 " " .	2.55 "
Blasting . .	11.15 "	50 " " .	——
First iron taken .	11.50 "	60 " " .	——
Loading finished .	3.55 "	70 " " .	——
Dropped bottom .	4.45 "	80 " " .	——

This is a melting of forty-seven tons in four hours and thirty-five minutes, or ten and a half tons per hour, and over eleven pounds of iron to one pound of coke. It should also be noted that the first ten tons took one hour and fifteen minutes; the second ten tons, one hour and ten minutes; the third ten tons, one hour,—showing a decrease of time as the operation advanced; that is to say, a better working of the cupola at the end of the operation than at the beginning.

The following is a statement giving total amount of iron melted, and coke used to melt the same, at the Rochester Car-wheel Works, during the month of September, 1883:—

1883.	Pounds Coke.	Pounds Iron.	1883.	Pounds Coke.	Pounds Iron.
Sept. 1 . .	4,850	49,708	Sept. 17 . .	5,500	59,024
" 3 . .	4,850	49,980	" 18 . .	5,500	59,024
" 4 . .	4,850	49,966	" 19 . .	5,500	59,041
" 5 . .	4,850	49,966	" 20 . .	5,500	59,041
" 6 . .	4,850	49,751	" 21 . .	5,500	59,041
" 7 . .	4,850	49,953	" 22 . .	5,500	59,041
" 8 . .	4,850	49,952	" 24 . .	5,500	59,041
" 10 . .	4,850	49,952	" 25 . .	5,500	59,041
" 11 . .	4,850	50,082	" 26 . .	5,500	59,041
" 12 . .	4,850	50,083	" 27 . .	5,500	59,041
" 13 . .	4,850	48,937	" 28 . .	5,500	59,041
" 14 . .	4,850	48,937	" 29 . .	5,500	59,041
" 15 . .	4,850	48,937	Total . . .	129,050	1,354,662

Just about 10½ to 1 in twenty-five consecutive days.

The advantages of the two cupolas illustrated may be summed up in the following manner:—

1st. A saving of from twenty to fifty per cent. of fuel, by securing more perfect combustion at the melting-point.

2d. The iron is improved by the melting, and a pure, uniform metal is obtained.

3d. Much greater rapidity of fusion, often doubling the ordinary cupola capacity.

4th. Hot fluid-iron all through the heat.

5th. Concentration of the fire in the smallest possible compass. The metal in fusion has less space to traverse while exposed to the oxidizing influence of the blast. This insures tougher castings, and less waste by oxidation in the furnace.

6th. The improvements can be applied to ordinary cupolas in a few days, and without difficulty.

7th. By this process the cupola does not clog. Melting is practically continuous as long as desired. One hundred tons of iron have been melted in one 58-inch cupola in six hours and a half, and the cupola remained in perfect condition at the end.

8th. A perfect "chilling iron" can be relied upon when desired.

9th. In the practical use of these cupolas, there is no fire to be seen at the loading doors, and no throwing-off of combustible gases — carbonic-acid gases alone escaping; the top of the cupolas being as cool as if there were no fire below.

In brief, the operation of melting iron in foundries has at length been taken out of the realm of guess-work and uncertainty, and placed upon the ground-floor of plain, practical, economical common-sense.

CHAPTER XXIV.

HINTS FOR DRAUGHTSMEN AND PATTERN-MAKERS.

The surface of a sphere equals the square of the circumference multiplied by 0.3183.

The diameter of a sphere equals the square root of its surface multiplied by 0.56419.

The side of an inscribed cube equals the radius multiplied by 1.1547.

The diameter of a circle equals the square root of the area multiplied by 1.12838.

The diameter of a sphere equals the cube root of its solidity multiplied by 1.2407.

The circumference of a circle equals the diameter multiplied by 3.1416, which is the ratio of the circumference to the diameter.

The area of a triangle equals the base multiplied by one-half of its height.

The diameter of a circle equals the circumference multipled by 0.31831.

The side of an inscribed equilateral triangle equals the diameter of the circle multiplied by 0.86.

The surface equals the product of the diameter and circumference.

The radius of a circle equals the circumference multiplied by 0.159155.

The circumference of a circle multiplied by 0.282 equals one side of a square of the same area.

The area of a circle equals the square of the radius multiplied by 3.1416.

The square root of the surface of a sphere multiplied by 1.772454 equals the circumference.

The area of a circle equals one-quarter of the diameter multiplied by the circumference.

The area of an ellipse equals the product of both diameters and .7854.

The radius of a circle equals the square root of the area multiplied by 0.56419.

The circumference of a sphere equals the cube root of its solidity multiplied by 3.8978.

The side of a square equals the diameter of a circle of the same area multiplied by 0.8862.

The side of an inscribed square equals the diameter multiplied by 0.7071.

TABLES OF WEIGHTS AND MEASURES.

LONG MEASURE.

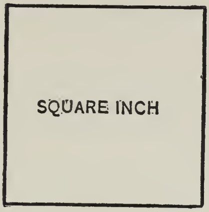
This table is used in measuring distances. The smaller units are the inch (one inch.) and its subdivision.

12 inches make 1 foot (marked ft.).
3 feet make 1 yard (marked yd.).
$5\frac{1}{2}$ yards make 1 rod or pole (marked rd.).
40 rods make 1 furlong (marked fur.).
8 furlongs make 1 mile (marked m.).
3 miles make 1 league (marked lea.).
$67\frac{1}{4}$ miles (nearly) } make 1 degree (marked deg.) of the
60 nautical miles } circumference of the earth.
360 degrees make 1 circumference (marked circ.).
An acre contains 4,840 square yards.
209 feet long by 209 feet broad is 1 acre.
A mile is 5,280 feet, or 1,760 yards.
A fathom is 6 feet.
A cubit is 2 feet.
A hand is 4 inches.
A space is 3 feet.
A span is $10\frac{7}{8}$ inches.
$16\frac{1}{2}$ feet make 1 rod.
4 rods make 1 chain.
10 chains make 1 furlong.

SQUARE MEASURE.

Square Measure is used for measuring surfaces. The square inch is the smallest unit in the table.

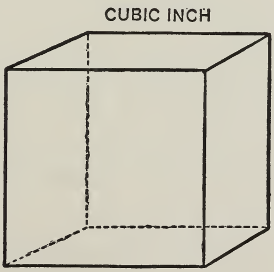
144 square inches (sq. in.) make 1 square foot (marked sq. ft.).



9 square feet make 1 square yard (marked sq. yd.).
$30\frac{1}{4}$ square yards make 1 square rod or perch (marked P.).
40 square rods make 1 rood (marked R.).
4 roods make 1 acre (marked A.).
640 acres make 1 square mile (marked sq. m.).

SOLID OR CUBIC MEASURE.

This measure is used in measuring timber and stone, and gives the unit for liquid and dry measure, and measures weights and coins.



1,728 cubic inches (cu. in.) make one cubic foot (marked cu. ft.).
27 cubic feet make 1 cubic yard (marked cu. yd.).
16 cubic feet make 1 cord foot (marked co. ft.).
8 cord feet, or 128 cubic feet, make 1 cord of wood (marked C.).

A pile of wood 4 feet high, 4 feet broad, and 8 feet long makes one cord.

40 cubic feet of round timber, or 50 cubic feet of hewn timber, makes one ton.

A box 3×4 inches, $2\frac{1}{2}$ inches deep, contains one quart.

A box 4×4 inches, $4\frac{1}{2}$ inches deep, contains one half peck.

A box $8 \times 8\frac{1}{2}$ inches, 8 inches deep, contains one peck.

A box $16 \times 16\frac{1}{2}$ inches, 13 inches deep, contains one bushel.

A box 16×24 inches, 22 inches deep, contains one barrel.

282 cubic inches, one gallon of ale.

231 cubic inches, one gallon of wine.

$268\frac{4}{5}$ cubic inches, one dry gallon.

$2{,}150\frac{2}{5}$ cubic inches, one bushel.

CLOTH MEASURE.

This measure is used in measuring cloth and other articles sold by the yard. The yard and inch are the same in this as in Long Measure.

$2\frac{1}{4}$ inches (in.) make 1 nail (marked na.).
4 nails make 1 quarter of a yard (marked qr.).
4 quarters make 1 yard (marked yd.).
5 quarters make 1 ell English (marked E. E.).

LIQUID OR WINE MEASURE.

This measure is used in measuring all kinds of liquids. The wine pint-cup will hold $28\frac{4}{5}$ cubic inches.

4 gills (gi.) make 1 pint (marked pt.).
2 pints make 1 quart (marked qt.).
4 quarts make 1 gallon (marked gal.).

63 gallons make 1 hogshead (marked hhd.).
2 hogsheads make 1 pipe (marked pi.).
2 pipes make 1 tun (marked tun).

DRY MEASURE.

This measure is used in measuring grain, fruit, coal, salt, etc. A pint-cup of this measure contains $33\frac{3}{5}$ cubic inches.

2 pints make 1 quart (marked qt.).
8 quarts make 1 peck (marked pk.).
4 pecks make 1 bushel (marked bu.).

TROY WEIGHT.

Troy Weight is used in weighing gold, silver, and jewels. The Troy pound is a piece of brass or other metal, which weighs as much as $22\frac{4}{5}$ cubic inches of water at a certain temperature.

24 grains (gr.) make 1 pennyweight (marked pwt.).
20 pennyweights make 1 ounce (marked oz.).
12 ounces make 1 pound (marked lb.).

APOTHECARIES' WEIGHT.

The Troy pound is sometimes divided differently to weigh medicines in mixing them. The pound, ounce, and grain are the same in Troy and Apothecaries' Weight.

20 grains (gr.) make 1 scruple (marked sc.).
3 scruples make 1 dram (marked dr.).
8 drams make 1 ounce (marked oz.).
12 ounces make one pound (marked lb.).

AVOIRDUPOIS WEIGHT.

This weight is used in all ordinary weighing. The avoirdupois pound is heavier than the Troy pound, 144 avoirdupois pounds being equal to 175 Troy pounds.

16 drams make 1 ounce (marked oz.).
16 ounces make 1 pound (marked lb.).
25 pounds make 1 quarter (marked qr.).
4 quarters, or 100 pounds, make 1 hundred weight (marked cwt.).
20 hundred weight make 1 ton (marked T.).

COMMERCIAL MEASURE.

16 drachms	1 ounce.
16 ounces	1 pound.
14 pounds	1 stone.
28 pounds	1 quarter.
4 quarters	1 cwt.
2,240 pounds	1 ton.

LIQUID MEASURE.

$31\frac{1}{2}$ gallons	1 barrel.
63 gallons	1 hogshead.
42 gallons	1 tierce.
84 gallons	1 puncheon.
252 gallons	1 tun.

UNITED STATES MONEY.

The units are coins of gold, silver, copper, and nickel, of fixed weight, size, and color.

10 mills make 1 cent (marked c.).
10 cents make 1 dime (marked d.).
10 dimes make 1 dollar (marked $).
10 dollars make 1 eagle (marked E.).

ENGLISH MONEY.

4 farthings (far.) make 1 penny (marked d.).
12 pence make 1 shilling (marked s.).
20 shillings make 1 pound (marked £).

The coins of this table are gold, silver, and copper.
A sovereign is a gold coin, — 1 pound or 20 shillings.
A guinea is equal to 21 shillings.
A pound is equal to $4.84 American money.

MEASURE OF TIME.

The natural units in this table are the day and the year. The smallest unit, the second, is the interval between two ticks of a clock, the pendulum being $39\frac{1}{10}$ inches long.

60 seconds (sec.) make 1 minute (marked min.).
60 minutes make 1 hour (marked hr.).
24 hours make 1 day (marked dy.).
7 days make 1 week (marked wk.).
365 days make 1 common year (marked yr.).
366 days make 1 leap year.
100 years make 1 century (marked c.).

The year is divided into twelve months.

First month, January, has 31 days.
Second month, February, has 28 days; in leap year, 29.
Third month, March, has 31 days.
Fourth month, April, has 30 days.
Fifth month, May, has 31 days.
Sixth month, June, has 30 days.
Seventh month, July, has 31 days.
Eighth month, August, has 31 days.
Ninth month, September, has 30 days.
Tenth month, October, has 31 days.
Eleventh month, November, has 30 days.
Twelfth month, December, has 31 days.

MISCELLANEOUS TABLE.

12 units make 1 dozen.
12 dozen make 1 gross.
20 units make 1 score.
24 sheets of paper make 1 quire.
20 quires make 1 ream.

THE FRENCH OR METRIC SYSTEM OF WEIGHTS AND MEASURES.

The great advantage of the French or metric system of weights and measures is the uniformity in the names and in the division of the units in the different tables.

The division is the successive division into tenths, after the manner of the eagle, dollar, dime, cent, and mill of the United States money. In addition to these advantages, this system has *one* table of weights instead of three; one table for cubic, liquid, and dry measure. The names of the units indicate what multiple or part of the principal unit they are.

LONG MEASURE.

The metre is the principal unit or basis of the table of Long Measure. The metre is 1 yard $3\frac{2}{5}$ inches, or $39\frac{37}{100}$ inches.

10 millimetres make 1 centimetre.
10 centimetres make 1 decimetre.
10 decimetres make 1 metre = $39\frac{37}{100}$ inches (marked M.).
10 metres make 1 decametre (marked D.).
10 decametres make 1 hectometre (marked H^m.).
10 hectometres make 1 kilometre (marked K^m.).
10 kilometres make 1 myriametre = $6\frac{21}{100}$ miles (marked M^m.).

The prefixes milli, centi, deci, mean $\frac{1}{1000}$, $\frac{1}{100}$, and $\frac{1}{10}$ respectively; the prefixes deca, hecto, kilo, myria, 10, 100, 1,000, 10,000, respectively. These are used in all the tables of this system. In commerce, the expressions, 10 metres, 100 metres, 1,000 metres, 10,000 metres, are invariably used instead of decametre, hectometre, kilometre.

SQUARE MEASURE.

The natural unit is the centiare, or square metre, equal to $1\frac{1}{5}$ square yards (nearly).

100 centiares make 1 are = 100 square metres.
10 ares make 1 decare.
10 decares make 1 hectare = $2\frac{47}{100}$ acres, $2\frac{1}{2}$ acres, nearly.

CUBIC MEASURE.

The unit of this table is the cubic metre = 1.3 cubic yards. This is called a stere when used in measuring wood, or hectolitre when applied to liquid or dry measure, of which the principal unit is the litre or cubic decimetre = $\frac{9}{10}$ of a quart, dry measure, and $1\frac{5}{100}$ of a quart, liquid measure.

10 millilitres make 1 centilitre = 10 cubic centimetres.
10 centilitres make 1 decilitre.
10 decilitres make 1 litre = 1 cubic decimetre = $\frac{9}{10}$ of a dry quart, D.M., $1\frac{5}{100}$ of a quart, L.M.
10 litres make 1 decalitre.
10 decalitres make 1 hectolitre.
10 hectolitres make 1 kilolitre or stere = 1 cubic metre.

WEIGHTS.

The principal unit is the gramme, or the weight of a millilitre of pure water when it is heaviest. The gramme is $15\frac{43}{100}$ grains avoirdupois.

10 milligrammes make 1 centigramme.

10 centigrammes make 1 decigramme.

10 decigrammes make 1 gramme = $15\frac{43}{100}$ grains avoirdupois.

10 grammes make 1 decagramme.

10 decagrammes make 1 hectogramme.

10 hectogrammes make 1 kilogramme = $2\frac{1}{5}$ lbs. avoirdupois.

10 kilogrammes make 1 myriagramme.

10 myriagrammes make 1 quintal.

10 quintals make 1 millier or tonneau = $1\frac{1}{10}$ tons, nearly.

TABLE OF FRENCH MONEY.

10 millimes make 1 centime.

100 centimes make 1 franc = 19 cents and 3 mills United States money.

20 francs make 1 louis.

5 centimes make 1 sou.

5 francs are nearly one dollar.

WEIGHTS.

A franc in silver weighs 5 grammes. 40 five-franc pieces in silver weigh one kilogramme.

MISCELLANEOUS RECIPES AND TABLES.

SHELLAC VARNISH FOR PATTERNS.

Dissolve good shellac or seed lac in alcohol, making the varnish of any consistence desired.

NOTE. — Shellac gives a pale cinnamon-colored varnish. Varnish made of seed lac is deeper-colored and redder. If colorless varnish is desired, use bleached shellac.

GLUE AND CEMENTS.

Glue is undoubtedly the most important cement used in the arts. Good glue is hard, clear (not necessarily light-colored, however), and free from bad taste and smell. Glue which is easily dissolved in *cold* water is not strong. Good glue merely swells in cold water, and must be heated to boiling-point before it will dissolve thoroughly. Great care must be taken not to burn it, and therefore it should always be prepared in a water-bath.

CEMENT FOR LEATHER BELTING.

Common glue and isinglass, equal parts, soaked for ten hours in just enough water to cover them. Bring gradually to boiling-heat, and add pure tannin until the whole becomes ropy, or appears like the white of eggs.

Buff off the surfaces to be joined, apply this cement warm, and clamp firmly.

CEMENT FOR ATTACHING LEATHER TO METAL.

Wash the metal with hot gelatine; steep the leather in an infusion of nut-galls (hot), and bring the two together.

CEMENT FOR CAST-IRON.

Take sal-ammoniac, 2 oz.; sublimed sulphur, 1 oz.; cast-iron filings or fine turnings, 1 lb. Mix in a mortar, and keep the powder dry.

When it is to be used, mix it with twenty times its weight of clean iron turnings or filings, and grind the whole in a mortar; then wet it with water until it becomes of convenient consistence, when it is to be applied to the joint. After a time it becomes as hard and strong as any part of the metal.

IRON CEMENT FOR CLOSING THE JOINTS OF IRON PIPES.

Take of iron borings, coarse powdered, 5 lbs.; powdered sal-ammoniac, 2 oz.; sulphur, 1 oz.; and water sufficient to moisten it.

This composition hardens rapidly; but, if time can be allowed, it sets more firmly without the sulphur. It must be used as soon as mixed, and rammed tightly into the joints.

BLACK VARNISH FOR CAST-IRON PATTERNS.

For objects to which it is applicable, one of the best black varnishes is obtained by applying boiled linseed oil to the iron, the latter being heated to a temperature that will just char or blacken the oil. The oil seems to enter the pores of the iron, and after such an application the metal resists rust and corrosive agents perfectly.

BLACK VARNISH FOR IRON-WORK.

Fuse 40 oz. of asphaltum, and add half a gallon of boiled linseed oil, 6 oz. red lead, 6 oz. litharge, and 4 oz. sulphate of zinc dried and powdered. Boil for two hours, and mix in 8 oz. fused dark amber gum and a pint of hot linseed oil, and boil again for two hours more. When the mass has thickened, withdraw the heat, and thin down with a gallon of turpentine.

WHITE HARD VARNISH FOR WOOD OR METAL.

Mastic, 2 oz.; sandarach, 8 oz.; elemi, 1 oz.; Strasbourg or Scio turpentine, 4 oz.; alcohol, 1 quart.

VARNISH FOR BRIGHT IRON-WORK.

Dissolve 3 lbs. of rosin in 10 pints boiled linseed oil, and add 2 lbs. of turpentine.

ALLOY FOR FILLING HOLES IN IRON.

Bismuth, one part; antimony, two parts; lead, nine parts. This alloy expands in cooling, so that when a hole is filled with the melted alloy the plug is not loose when it is cold.

MEASUREMENT OF LUMBER.

To find the superficial contents of boards, planks, scantlings, joists, and square timber, when the length is given in feet, and the width and thickness in inches.

Rule. — Multiply the length by the width, and divide the product by 12; or, in other words, take 12 for the unity term of a fraction, and the length and width for the unit term, and proceed in multiplication.

Example 1. — How many feet are there in a board 24′ long, 11″ wide, and 1″ thick?

Statement:—

$$\frac{\overset{2}{\cancel{24}} \times 11}{\cancel{12}} = 22'.$$

Example 2.—How many feet in a board 20′ long and 16″ wide?

Statement:—

$$\frac{20 \times \overset{4}{\cancel{16}}}{\underset{3}{\cancel{12}}} = 26'\,8''.$$

Simply $\frac{4}{3} \times 20 = 26'\,8''$, or $\frac{5}{3} \times 16 = 26'\,8''$.

Example 3.—How many feet in 13 boards 24′ long and 20″ wide?

Statement:—

$$\frac{\overset{2}{\cancel{24}} \times 20 \times 13}{\cancel{12}} = 520'.$$

The 12 is contained in 24 2 times; $2 \times 20 \times 13 = 520$, the number of feet.

Example 4.—Find the contents, in board measure, of a plank 18′ long, 10″ wide, and 2″ thick.

Statement:—

$$\frac{\overset{3}{\cancel{18}} \times 10 \times \cancel{2}}{\underset{\cancel{6}}{\cancel{12}}} = 30'.$$

Example 5.—How many feet in 90 pieces of scantling 2″ × 3″ × 16′ long?

Statement:—

$$\frac{90 \times 2 \times \cancel{3} \times \overset{4}{\cancel{16}}}{\underset{\cancel{4}}{\cancel{12}}} = 720'.$$

Example 6. — How many feet in a stick of timber 7 × 10, and 16′ long?

Statement: —

$$\frac{7 \times 10 \times \overset{2}{\cancel{24}}}{\cancel{12}} = 140'.$$

SQUARE AND ROUND TIMBER.

To find the cubical contents of square timber.

RULE. — Take 12 × 12 for the unity term of a fraction and the indicated product of the area of one end in inches, and the length in feet for the unit term.

Example. — Find the cubical contents of a stick of timber 16 × 16 × 36.

Statement: —

$$\frac{16 \times \overset{4}{\cancel{16}} \times \overset{\cancel{3}}{\cancel{36}}}{\underset{\cancel{4}}{\cancel{12}} \times \cancel{12}} = 64'.$$

For round timber, to reduce it to square timber.

RULE. — From the mean diameter subtract its third part, square the remainder, and the product of that result into the length, divided by 12 × 12, gives the cubical contents in square timber.

NOTE. — To find the mean diameter, add the two ends together, and divide by two.

EXPANSION OF METALS.

Metals expand by heat, and contract by cold; and in almost all mechanical operations, unless the tendency to expand is allowed to act, very great strains are brought to bear upon the material.

The following table shows the amount of expansion for metals per foot: —

	Expansion per Degree Fah.	Expansion from 32° to 212°.
Iron	.0000067	.00122
Steel	.0000069	.00124
Copper	.0000090	.00171
Zinc	.0000160	.00294
Tin	.0000190	.00217

Almost all solid bodies expand equally for each degree between freezing and boiling, or from 32° to 212° of Fahrenheit's thermometer. A bar of iron therefore, which is 12 feet long, by an increase of 60° of temperature becomes $50 \times 12 \times .0000067 = 12.0048$ feet in length.

APPROXIMATE RULES FOR FINDING THE WEIGHT OF ROUND, SQUARE, AND RECTANGULAR BEAMS, BARS, ETC., OF CAST-IRON.

Rule 1. — Multiply the square of the diameter in inches by the length in feet and 2.48, and the product will be the weight in pounds avoirdupois.

The dimensions of a cast-iron ring being given, to find its weight: —

Rule. — Multiply the breadth of the ring added to the inner diameter by .0074, and that again by the breadth and by the thickness, and the product will be its weight in hundred-weight.

To find the weight of any cast-iron ball whose diameter is given: —

Rule. — Multiply the cube of the diameter in inches by .1377, and the product will be the weight in pounds avoirdupois.

To find the diameter of a cast-iron ball when the weight is given: —

Rule. — Multiply the cube root of the weight in pounds by 1.936, and the product will be the diameter in inches.

RULES FOR CALCULATING THE SPEED OF GEARS OR PULLEYS.

In calculating for gears, multiply or divide by the number of teeth, as may be required. In calculating for pulleys, multiply or divide by their diameter in inches.

The driving-wheel is called the driver, and the driven-wheel the driven.

PROBLEM 1. — The revolutions of driver and driven, and the diameter of driven, being given, required the diameter of driver.

RULE. — Multiply the diameter of driven by its number of revolutions, and divide by the number of revolutions of the driver.

PROBLEM 2. — The diameter and revolutions of the driver being given, required the diameter of the driven to make a given number of revolutions in the same time.

RULE. — Multiply the diameter of the driver by its number of revolutions, and divide the product by the required number of revolutions.

PROBLEM 3. — The diameter or number of teeth and number of revolutions of the driver, with the diameter or number of teeth of the driven, being given, required the revolutions of the driven.

RULE. — Multiply the diameter or number of teeth of the driver by its number of revolutions, and divide by the diameter or number of teeth of the driven.

PROBLEM 4. — The diameter of driver and driven, and the number of revolutions of driven, being given, required the number of revolutions of the driver.

RULE. — Multiply the diameter of driven by its number of revolutions, and divide by the diameter of the driver.

TABLE OF THE WEIGHT AND STRENGTH OF CHAINS.

Inch.	Weight per foot.	Safe Weight in pounds.	Inch.	Weight per foot.	Safe Weight in pounds.
$\frac{1}{8}$	0.17	250	$\frac{5}{8}$	4.0	6,250
$\frac{3}{16}$	0.38	560	$\frac{11}{16}$	4.84	7,550
$\frac{1}{4}$	0.67	1,000	$\frac{3}{4}$	5.75	9,000
$\frac{5}{16}$	1.08	1,560	$\frac{13}{16}$	6.0	10,500
$\frac{3}{8}$	1.55	2,250	$\frac{7}{8}$	7.83	12,250
$\frac{7}{16}$	2.11	3,050	$\frac{15}{16}$	9.4	14,000
$\frac{1}{2}$	2.7	4,000	1	10.07	16,000
$\frac{9}{16}$	3.42	5,050			

MELTING POINT OF METALS.

Name.	Degrees Fah.	Authority.
Platina	4,593	–
Antimony . . .	955–842	J. Lowthian Bell.
Bismuth	487–507	" "
Tin (average) . .	475	–
Lead	622–620	J. Lowthian Bell.
Zinc	772–782	" "
Cast-iron	2,786–{1,922–2,012, white; 2,012–1,922, gray}	Pouillet.
Wrought-iron . .	2,552–2,733, welding heat.	"
Copper (average) .	2,174	–

AVERAGE SHRINKAGE OF CAST METALS.

Steam-engine cylinders	$\frac{1}{12}''$ in $1'$.
Steam-engine frames	$\frac{1}{10}''$ in $1'$.
In pipes	$\frac{1}{8}''$ in $1'$.
In thin brass	$\frac{1}{7}''$ in $1'$.
In thick brass	$\frac{1}{8}''$ in $1'$.
In steel	$\frac{1}{16}''$ in $1'$.
In copper	$\frac{7}{32}''$ in $1'$.
In tin	$\frac{9}{32}''$ in $1'$.
In zinc	$\frac{5}{16}''$ in $1'$.
In lead	$\frac{5}{16}''$ in $1'$.

STRENGTH OF MATERIALS OF CONSTRUCTION.

The ultimate resistance in pounds per square inch of section, of various materials for construction, are as follows: —

Name of Material.	Resistance to Extension.	Resistance to Compression.	Tensile strength in Practice.	Comparative strength in Practice.
White pine	10,000	6,000	2,000	1,200
White oak	15,000	7,500	3,000	1,500
Rock elm	16,000	8,011	3,200	1,602
Wrought-iron	60,000	50,000	12,000	15,000
Cast-iron	20,000	100,000	4,000	20,000

PRACTICAL TABLES FOR GENERAL USE.

LAP-WELDED AMERICAN CHARCOAL IRON BOILER TUBES.

External diameter.	Standard thickness.	Internal diameter.	Internal circumference.	External circumference.	* Length of pipe per sq. ft. of inside surface.	* Length of pipe per sq. ft. of outside surface.	Internal area.	External area.	Weight per foot.
Ins.	Ins.	Ins.	Ins.	Ins.	Feet.	Feet.	Ins.	Ins.	lbs.
1	0.072	0.856	2.689	3.142	4.460	3.819	0.575	0.785	0.708
1¼	0.072	1.106	3.474	3.927	3.455	3.056	0.960	1.227	0.900
1½	0.083	1.334	4.191	4.712	2.863	2.547	1.396	1.767	1.250
1¾	0.095	1.560	4.901	5.498	2.448	2.183	1.911	2.405	1.665
2	0.098	1.804	5.667	6.283	2.118	1.909	2.556	3.142	1.981
2¼	0.098	2.054	6.484	7.069	1.850	1.698	3.314	3.976	2.238
2½	0.109	2.283	7.172	7.854	1.673	1.528	4.094	4.909	2.755
2¾	0.109	2.533	7.957	8.639	1.508	1.390	5.039	5.940	3.045
3	0.109	2.783	8.743	9.425	1.373	1.273	6.083	7.069	3.333
3¼	0.119	3.012	9.462	10.210	1.268	1.175	7.125	8.296	3.958
3½	0.119	3.262	10.248	10.995	1.171	1.091	8.357	9.621	4.272
3¾	0.119	3.512	11.033	11.781	1.088	1.018	9.687	11.045	4.590
4	0.130	3.741	11.753	12.566	1.023	0.955	10.992	12.566	5.320
4½	0.130	4.241	13.323	14.137	0.901	0.849	14.126	15.904	6.010
5	0.140	4.720	14.818	15.708	0.809	0.764	17.497	19.635	7.226
6	0.151	5.699	17.904	18.849	0.670	0.637	25.509	28.274	9.346
7	0.172	6.657	20.914	21.991	0.574	0.545	34.805	38.484	12.435
8	0.182	7.636	23.989	25.132	0.500	0.478	45.795	50.265	15.109
9	0.193	8.615	27.055	28.274	0.444	0.424	58.291	63.617	18.002
10	0.214	9.573	30.074	31.416	0.399	0.382	71.975	78.540	22.190

* In estimating the effective steam-heating or boiler surface of tubes, the surface in contact with air or gases of combustion (whether internal or external to the tubes) is to be taken. For heating liquids by steam, super-heating steam, or transferring heat from one liquid or one gas to another, the mean surface of the tubes is to be taken.

WROUGHT-IRON WELDED TUBES.

For Steam, Gas, or Water.

Nominal Diameter.	Actual Inside Diameter.	Actual Outside Diameter.	Thickness.	Weight per Foot of Length.	Number of Threads per Inch of Screw.
Inches.	Inches.	Inches.	Inches.	lbs.	
$\frac{1}{8}$	.270	.405	.068	.243	27
$\frac{1}{4}$	.364	.54	.088	.422	18
$\frac{3}{8}$	.494	.675	.091	.561	18
$\frac{1}{2}$	.623	.84	.109	.845	14
$\frac{3}{4}$	.824	1.05	.113	1.126	14
1	1.048	1.315	.134	1.670	$11\frac{1}{2}$
$1\frac{1}{4}$	1.380	1.66	.140	2.258	$11\frac{1}{2}$
$1\frac{1}{2}$	1.611	1.9	.145	2.694	$11\frac{1}{2}$
2	2.067	2.375	.154	3.667	$11\frac{1}{2}$
$2\frac{1}{2}$	2.468	2.875	.204	5.773	8
3	3.067	3.5	.217	7.547	8
$3\frac{1}{2}$	3.548	4	.226	9.055	8
4	4.026	4.5	.237	10.728	8
$4\frac{1}{2}$	4.508	5	.247	12.492	8
5	5.045	5.563	.259	14.564	8
6	6.065	6.625	.280	18.767	8
7	7.023	7.625	.301	23.410	8
8	7.982	8.625	.322	28.348	8
9	9.001	9.688	.344	34.077	8
10	10.019	10.75	.366	40.641	8

TABLE OF THE WEIGHT AND STRENGTH OF MANILA CORDAGE.

Size Circumference. Inches.	Size Diameter. Inches.	Weight of 100 fathoms.	Feet in one pound.	Breaking strain of new ropes. Pounds.	Tarred Hemp. Weight of 100 fathoms.
$1\frac{1}{4}$	$\frac{3}{8}$	31	20	For ropes in use deduct $\frac{1}{3}$ from these figures for chafing, etc.	–
$1\frac{1}{2}$	$\frac{1}{2}$	44	14		40
$1\frac{3}{4}$	$\frac{9}{16}$	60	10		75
2	$\frac{5}{8}$	79	$7\frac{1}{2}$	3,000	100
$2\frac{1}{4}$	$\frac{3}{4}$	99	6	4,000	125
$2\frac{1}{2}$	$\frac{13}{16}$	122	5	5,000	155
$2\frac{3}{4}$	$\frac{7}{8}$	146	4	6,000	190
3	1	176	$3\frac{3}{8}$	7,000	225
$3\frac{1}{4}$	$1\frac{1}{16}$	270	3	8,500	265
$3\frac{1}{2}$	$1\frac{1}{8}$	240	$2\frac{1}{2}$	9,500	300
$3\frac{3}{4}$	$1\frac{1}{4}$	275	$2\frac{1}{6}$	11,000	355
4	$1\frac{5}{16}$	305	2	12,500	405
$4\frac{1}{4}$	$1\frac{3}{8}$	355	$1\frac{8}{12}$	14,000	455
$4\frac{1}{2}$	$1\frac{1}{2}$	395	$1\frac{1}{2}$	16,000	500
5	$1\frac{5}{8}$	490	$1\frac{1}{4}$	20,000	630
$5\frac{1}{2}$	$1\frac{3}{4}$	595	1	24,000	750
6	2	705	10″	27,000	910
$6\frac{1}{2}$	$2\frac{1}{8}$	825	$8\frac{1}{2}$″	31,500	1,050
7	$2\frac{1}{4}$	960	$7\frac{1}{2}$″	37,000	1,235
$7\frac{1}{2}$	$2\frac{1}{2}$	1,100	$6\frac{1}{2}$″	42,500	1,400
8	$2\frac{5}{8}$	1,255	$5\frac{1}{2}$″	48,500	1,600
$8\frac{1}{2}$	$2\frac{7}{8}$	1,415	5″	54,500	1,820
9	3	1,585	$4\frac{1}{2}$″	61,500	2,050

CAST-IRON PIPES, TWELVE INCHES LONG.

Thickness of Metal.

Bore.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$	$1\frac{1}{8}''$	$1\frac{1}{4}''$
Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	3.1	5.1	7.4	10.0	12.9	16.1	19.6	23.5	27.6
$1\frac{1}{4}$	3.7	6.0	8.6	11.5	14.7	18.3	22.1	26.2	30.7
$1\frac{1}{8}$	4.3	6.9	9.8	13.0	16.6	20.4	24.5	29.0	33.7
$1\frac{3}{4}$	4.9	7.8	11.1	14.6	18.4	22.6	27.0	31.8	36.8
2	5.5	8.8	12.3	16.1	20.3	24.7	29.5	34.5	39.9
$2\frac{1}{4}$	6.1	9.7	13.5	17.6	22.1	26.8	31.9	37.3	43.0
$2\frac{1}{2}$	6.7	10.6	14.7	19.2	23.9	28.9	34.4	40.0	46.0
$2\frac{3}{4}$	7.4	11.5	16.0	20.7	25.7	31.1	36.8	42.8	49.1
3	8.0	12.4	17.2	22.2	27.6	33.3	39.3	45.6	52.2
$3\frac{1}{4}$	8.6	12.3	18.4	23.8	29.5	35.4	41.7	48.3	55.2
$3\frac{1}{2}$	9.2	14.2	19.6	25.3	31.3	37.6	44.2	51.1	58.3
$3\frac{3}{4}$	9.8	15.2	20.9	26.9	33.1	39.7	46.6	53.8	61.4
4	10.4	16.1	22.1	28.4	35.0	41.9	49.1	56.6	64.4
$4\frac{1}{4}$	11.1	17.1	23.4	30.0	36.9	44.1	51.6	59.4	67.6
$4\frac{1}{2}$	11.7	18.0	24.5	31.4	38.7	46.2	54.0	62.1	70.6
$4\frac{3}{4}$	12.3	18.9	25.8	33.0	40.5	48.3	56.5	64.9	73.6
5	12.9	19.8	27.0	34.5	42.3	50.5	58.9	67.6	76.7
$5\frac{1}{4}$	13.5	20.7	28.2	36.1	44.2	52.6	61.4	70.4	79.8
$5\frac{1}{2}$	14.1	21.6	29.5	37.6	46.0	54.8	63.8	73.2	82.8
$5\frac{3}{4}$	14.7	22.6	30.7	39.1	47.9	56.9	66.3	76.0	85.9
6	15.3	23.5	31.9	40.7	49.7	59.1	68.7	78.7	88.8
$6\frac{1}{4}$	16.0	24.4	33.1	42.2	51.5	61.2	71.2	81.2	92.0
$6\frac{1}{2}$	16.6	25.3	34.4	43.7	53.4	63.4	73.4	84.2	95.1
$6\frac{3}{4}$	17.2	26.2	35.6	45.3	55.2	65.3	76.1	87.0	98.2
7	17.8	27.2	36.8	46.8	56.8	67.7	78.5	89.7	101.2
$7\frac{1}{4}$	18.4	28.1	38.1	48.1	58.9	69.8	81.0	92.5	104.2
$7\frac{1}{2}$	19.0	29.0	39.1	49.9	60.7	72.0	83.5	95.3	107.4
$7\frac{3}{4}$	19.6	29.7	40.5	51.4	62.6	74.1	85.9	98.0	110.5
8	20.0	30.8	41.7	52.9	64.4	76.2	88.4	100.8	113.5
$8\frac{1}{4}$	20.9	31.7	43.0	54.5	66.3	78.4	90.8	103.5	116.6
$8\frac{1}{2}$	21.7	32.9	44.4	56.2	68.3	80.8	93.5	106.5	119.9
$8\frac{3}{4}$	22.1	33.6	45.4	57.5	70.0	82.7	95.7	109.1	122.7
9	22.7	34.5	46.6	59.1	71.8	84.8	98.2	111.8	125.8
$9\frac{1}{4}$	23.3	35.4	47.9	60.6	73.6	87.0	100.6	114.6	128.9
$9\frac{1}{2}$	23.9	36.4	49.1	62.1	75.5	89.1	103.1	117.4	131.9

CAST-IRON PIPES, — *Concluded.*

Bore.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	1″	$1\frac{1}{8}''$	$1\frac{1}{4}''$
$9\frac{3}{4}$	24.6	37.3	50.3	63.7	77.3	91.3	105.5	120.1	135.0
10	25.2	38.2	51.5	65.2	79.2	93.4	108.0	122.8	138.1
$10\frac{1}{4}$	25.8	39.1	52.8	66.7	81.0	95.6	110.4	125.6	141.1
$10\frac{1}{2}$	26.4	40.0	54.0	68.3	82.8	97.7	112.9	128.4	144.2
$10\frac{3}{4}$	27.0	41.0	55.2	69.8	84.7	99.9	115.4	131.2	147.3
11	27.6	41.9	56.5	71.3	86.5	102.0	117.8	133.9	150.3
$11\frac{1}{4}$	28.2	42.8	57.7	72.9	88.4	104.2	120.3	136.7	153.4
$11\frac{1}{2}$	28.8	43.7	58.9	74.4	90.2	106.3	122.7	139.4	156.4
$11\frac{3}{4}$	29.5	44.6	60.1	75.9	92.0	108.5	125.2	142.2	159.5
12	30.1	45.6	61.4	77.5	93.6	110.6	127.6	145.0	162.6
13	–	–	–	82.7	101.2	118.2	137.4	154.1	173.5
14	–	–	–	89.3	108.2	126.5	146.2	165.3	185.2
15	–	–	–	95.2	115.7	135.3	156.2	176.2	198.1
16	–	–	–	–	123.3	143.1	166.1	187.5	211.3
17	–	–	–	–	130.2	152.5	178.5	198.2	223.4
18	–	–	–	–	137.0	161.2	185.3	209.1	235.6
19	–	–	–	–	–	169.2	195.7	222.3	247.1
20	–	–	–	–	–	178.1	205.2	233.2	259.0
21	–	–	–	–	–	–	214.1	243.5	273.2
22	–	–	–	–	–	–	223.0	254.8	285.4
23	–	–	–	–	–	–	233.4	265.5	298.3
24	–	–	–	–	–	–	245.2	277.5	310.6

NOTE. — The first column is the bore of the pipes, expressed in inches and parts of an inch; and the remaining columns are the weights of the pipes under the different thicknesses in which they are placed.

N. B. — Two flanges are generally reckoned equal to one foot of pipe.

SIZE OF NAILS.

The following table will show the length of the various sizes and the number of nails in a pound. They are rated "3-penny" up to "20-penny." The first column gives the

number, the second the length in inches, and the third the number per pound: —

Number.	Length in inches.	No. per pound.	Number.	Length in inches.	No. per pound.
3-penny .	1	557	12-penny .	2	54
4-penny .	$1\frac{1}{4}$	353	20-penny .	$3\frac{1}{2}$	34
5-penny .	$1\frac{3}{4}$	232	Spikes . .	4	16
6-penny .	2	167	Spikes . .	$4\frac{1}{2}$	12
7-penny .	$2\frac{1}{4}$	141	Spikes . .	5	10
8-penny .	$2\frac{1}{2}$	101	Spikes . .	6	7
10-penny .	$2\frac{3}{4}$	68	Spikes . .	7	5

TABLE OF THE WEIGHT OF CAST-IRON BALLS

In pounds avoirdupois, from 1″ to 12″ diameter, and advancing by an eighth.

Inch.	Lbs. and parts.	Inch.	Lbs. and parts.	Inch.	Lbs. and parts.	Inch.	Lbs. and parts.	Inch.	Lbs. and parts.
1	.14	$3\frac{1}{4}$	4.72	$5\frac{1}{2}$	22.91	$7\frac{3}{4}$	64.09	10	137.71
$1\frac{1}{8}$	.20	$3\frac{3}{8}$	5.29	$5\frac{5}{8}$	24.51	$7\frac{7}{8}$	67.25	$10\frac{1}{8}$	142.91
$1\frac{1}{4}$	.27	$3\frac{1}{2}$	5.80	$5\frac{3}{4}$	26.18	8	70.49	$10\frac{1}{4}$	148.28
$1\frac{3}{8}$	.37	$3\frac{5}{8}$	6.56	$5\frac{7}{8}$	27.91	$8\frac{1}{8}$	73.85	$10\frac{3}{8}$	153.78
$1\frac{1}{2}$	.47	$3\frac{3}{4}$	7.26	6	29.72	$8\frac{1}{4}$	77.32	$10\frac{1}{2}$	159.40
$1\frac{5}{8}$	.59	$3\frac{7}{8}$	8.01	$6\frac{1}{8}$	31.64	$8\frac{3}{8}$	80.88	$10\frac{5}{8}$	165.16
$1\frac{3}{4}$	.74	4	8.81	$6\frac{1}{4}$	33.62	$8\frac{1}{2}$	84.56	$10\frac{3}{4}$	171.05
$1\frac{7}{8}$	.91	$4\frac{1}{8}$	9.67	$6\frac{3}{8}$	35.67	$8\frac{5}{8}$	88.34	$10\frac{7}{8}$	177.10
2	1.10	$4\frac{1}{4}$	10.57	$6\frac{1}{2}$	37.80	$8\frac{3}{4}$	92.24	11	183.29
$2\frac{1}{8}$	1.32	$4\frac{3}{8}$	11.53	$6\frac{5}{8}$	40.10	$8\frac{7}{8}$	96.26	$11\frac{1}{8}$	189.60
$2\frac{1}{4}$	1.57	$4\frac{1}{2}$	12.55	$6\frac{3}{4}$	42.35	9	100.39	$11\frac{1}{4}$	196.10
$2\frac{3}{8}$	1.84	$4\frac{5}{8}$	13.62	$6\frac{7}{8}$	44.74	$9\frac{1}{8}$	104.62	$11\frac{3}{8}$	202.67
$2\frac{1}{2}$	2.15	$4\frac{3}{4}$	14.76	7	47.21	$9\frac{1}{4}$	108.98	$11\frac{1}{2}$	209.43
$2\frac{5}{8}$	2.49	$4\frac{7}{8}$	15.95	$7\frac{1}{8}$	49.79	$9\frac{3}{8}$	113.46	$11\frac{5}{8}$	216.32
$2\frac{3}{4}$	2.86	5	17.12	$7\frac{1}{4}$	52.47	$9\frac{1}{2}$	118.06	$11\frac{3}{4}$	223.40
$2\frac{7}{8}$	3.27	$5\frac{1}{8}$	18.54	$7\frac{3}{8}$	55.23	$9\frac{5}{8}$	122.77	$11\frac{7}{8}$	230.57
3	3.72	$5\frac{1}{4}$	19.93	$7\frac{1}{2}$	58.06	$9\frac{3}{4}$	127.63	12	237.94
$3\frac{1}{8}$	4.20	$5\frac{3}{8}$	21.39	$7\frac{5}{8}$	60.04	$9\frac{7}{8}$	132.60		

SQUARE IRON.

Size.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
¼	0.2	0.4	0.6	0.8	1.1	1.3	1.5	1.7	1.9
⅜	0.5	1.0	1.4	1.9	2.4	2.9	3.3	3.8	4.3
½	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6
⅝	1.3	2.6	4.0	5.3	6.6	7.9	9.2	10.6	11.9
¾	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1
⅞	2.6	5.2	7.8	10.4	12.9	15.5	18.1	20.7	23.3
1	3.4	6.8	10.1	13.5	16.9	20.3	23.7	27.0	30.4
1⅛	4.3	8.6	12.8	17.1	21.4	25.7	29.9	34.2	38.5
1¼	5.3	10.6	15.8	21.1	26.4	31.7	37.0	42.2	47.5
1⅜	6.4	12.8	19.2	25.6	32.0	38.3	44.7	51.1	57.5
1½	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4
1⅝	8.9	17.9	26.8	35.7	44.6	53.6	62.5	71.4	80.3
1¾	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.8	93.2
1⅞	11.9	23.8	35.6	47.5	59.4	71.3	83.2	95.1	106.9
2	13.5	27.0	40.6	54.1	67.6	81.1	94.6	108.2	121.7
2⅛	15.3	30.5	45.8	61.1	76.3	91.6	106.8	122.1	137.4
2¼	17.1	34.2	51.3	68.4	85.6	102.7	119.8	136.9	154.0
2⅜	19.1	38.1	57.2	76.3	95.3	114.4	133.5	152.5	171.6
2½	21.1	42.2	63.4	84.5	105.6	126.7	147.8	169.0	190.1
2⅝	23.3	46.6	69.9	93.2	116.5	139.8	163.0	186.3	209.6
2¾	25.6	51.1	76.7	102.2	127.8	153.4	178.9	204.5	230.0
2⅞	27.9	55.9	83.8	111.8	139.7	167.6	195.7	223.5	251.5
3	30.4	60.8	91.2	121.7	152.1	182.5	212.9	243.3	273.7
3⅛	33.0	66.0	99.0	132.0	165.1	198.1	231.1	264.1	297.1
3¼	35.7	71.4	107.1	142.8	178.5	214.2	249.9	285.6	321.3
3⅜	38.5	77.0	115.5	154.0	192.5	231.0	269.5	308.0	346.5
3½	41.4	82.8	124.2	165.6	207.0	248.4	289.8	331.3	372.7
3⅝	44.4	88.8	133.3	177.7	222.1	266.5	310.9	355.3	399.8
3¾	47.5	95.1	142.6	190.1	237.7	385.2	332.7	380.3	427.8
3⅞	50.8	101.5	152.3	203.0	253.8	304.5	355.3	406.0	456.8
4	54.1	108.2	162.3	216.3	270.4	324.5	378.6	432.7	486.8
4⅛	57.5	115.0	172.6	230.1	287.6	345.1	402.6	460.1	517.7
4¼	61.1	122.1	183.2	244.2	305.3	366.3	427.4	488.4	549.5
4⅜	64.7	129.4	194.1	258.8	323.5	388.2	452.9	517.6	582.3
4½	68.4	136.9	205.3	273.8	342.2	410.7	479.1	547.6	616.0
4⅝	72.3	144.6	216.9	289.2	361.5	433.8	506.1	578.4	650.7

SQUARE IRON, — *Concluded.*

Size.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
$4\frac{3}{4}$	76.3	152.5	228.8	305.1	381.3	457.6	533.8	610.1	686.4
$4\frac{7}{8}$	80.3	160.7	241.0	321.3	401.7	482.0	562.3	642.7	723.0
5	84.5	169.0	253.4	337.9	422.4	506.9	591.4	675.8	760.3
$5\frac{1}{8}$	88.8	177.6	266.4	355.1	443.9	532.7	621.5	710.3	799.1
$5\frac{1}{4}$	93.2	186.3	279.5	372.7	465.8	559.0	652.2	745.3	838.5
$5\frac{3}{8}$	97.7	195.3	293.0	390.6	488.3	585.9	683.6	781.3	878.9
$5\frac{1}{2}$	102.2	204.5	306.7	409.0	511.2	613.4	715.7	817.9	920.2
$5\frac{5}{8}$	107.0	213.5	320.9	427.8	534.8	641.7	748.7	855.6	962.6
$5\frac{3}{4}$	111.8	223.5	335.3	447.0	558.8	670.5	783.2	894.0	1005.8
$5\frac{7}{8}$	116.7	233.3	350.0	466.7	583.4	700.0	816.7	933.4	1050.0
6	121.7	243.3	365.0	486.7	608.3	730.0	841.6	973.3	1095.0
$6\frac{1}{4}$	132.0	264.1	396.1	528.2	660.2	792.2	924.3	1056.3	1188.4
$6\frac{1}{2}$	142.8	285.6	428.4	571.3	714.1	856.9	999.7	1142.5	1285.3
$6\frac{3}{4}$	154.0	308.0	462.0	616.0	770.1	924.1	1078.1	1232.1	1386.1
7	165.6	331.2	496.9	662.5	828.2	993.8	1159.4	1325.1	1490.7
$7\frac{1}{4}$	177.7	355.3	533.0	710.7	888.4	1066.0	1243.7	1421.4	1599.0
$7\frac{1}{2}$	190.1	380.3	570.4	760.5	950.7	1140.8	1331.0	1521.1	1711.2
$7\frac{3}{4}$	203.0	406.0	609.1	812.1	1015.1	1218.1	1421.2	1624.2	1827.2
8	216.3	432.7	649.0	865.3	1081.7	1298.0	1514.4	1730.7	1947.0
$8\frac{1}{4}$	230.1	460.1	690.2	920.3	1150.3	1380.4	1610.5	1840.5	2070.6
$8\frac{1}{2}$	244.2	488.4	732.7	976.9	1221.1	1465.3	1709.5	1953.8	2198.0
$8\frac{3}{4}$	258.8	517.6	776.4	1035.2	1294.0	1552.8	1811.6	2070.4	2329.2
9	273.8	547.6	821.4	1095.2	1369.0	1642.8	1916.5	2190.3	2464.1
$9\frac{1}{4}$	289.2	578.4	867.7	1156.9	1446.1	1735.3	2024.5	2313.8	2603.0
$9\frac{1}{2}$	305.1	610.1	915.2	1220.2	1525.3	1830.3	2135.4	2440.4	2745.5
$9\frac{3}{4}$	321.3	642.7	964.0	1285.3	1606.7	1928.0	2249.3	2570.7	2892.3
10	337.9	675.8	1013.8	1351.7	1689.6	2027.5	2315.4	2703.4	3041.0
$10\frac{1}{4}$	355.1	710.3	1065.4	1420.5	1775.7	2130.8	2486.0	2841.1	3196.2
$10\frac{1}{2}$	372.7	745.3	1118.0	1490.7	1863.4	2236.0	2608.7	2981.4	3354.0
$10\frac{3}{4}$	390.6	781.3	1171.9	1562.5	1953.1	2343.8	2734.4	3125.0	3515.7
11	409.0	817.9	1226.9	1635.8	2044.8	2453.8	2862.7	3271.7	3680.6
$11\frac{1}{4}$	427.8	855.6	1283.4	1711.2	2139.1	2566.9	2994.7	3422.5	3850.3
$11\frac{1}{2}$	447.0	894.0	1341.1	1788.1	2235.1	2682.1	3129.2	3576.2	4023.2
$11\frac{3}{4}$	466.7	933.4	1400.1	1866.7	2333.4	2800.1	3266.8	3733.5	4200.2
12	486.7	973.3	1460.0	1946.6	2433.3	2919.9	3406.6	3893.2	4379.9

ROUND IRON.

Size.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
$\frac{1}{4}$	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5
$\frac{3}{8}$	0.4	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.4
$\frac{1}{2}$	0.7	1.3	2.0	2.7	3.3	4.0	4.6	5.3	6.0
$\frac{5}{8}$	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	9.4
$\frac{3}{4}$	1.5	3.0	4.5	6.0	7.5	9.0	10.5	11.9	13.4
$\frac{7}{8}$	2.0	4.1	6.1	8.1	10.2	12.2	14.2	16.3	18.3
1	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2	23.9
$1\frac{1}{8}$	3.4	6.7	10.1	13.4	16.8	20.2	23.5	26.9	30.2
$1\frac{1}{4}$	4.2	8.3	12.5	16.7	20.9	25.0	29.2	33.4	37.5
$1\frac{3}{8}$	5.0	10.0	15.1	20.1	25.1	30.1	35.1	40.2	45.2
$1\frac{1}{2}$	6.0	11.9	17.9	23.9	29.9	35.8	41.8	47.8	53.7
$1\frac{5}{8}$	7.0	14.0	21.0	28.0	35.1	42.1	49.1	56.1	63.1
$1\frac{3}{4}$	8.1	16.3	24.4	32.5	40.6	48.8	56.9	65.0	73.2
$1\frac{7}{8}$	9.3	18.7	28.0	37.3	46.7	56.0	65.3	74.7	84.0
2	10.6	21.2	31.8	42.5	53.1	63.7	74.3	84.9	95.5
$2\frac{1}{8}$	12.0	24.0	36.0	48.0	59.9	71.9	83.9	95.9	107.9
$2\frac{1}{4}$	13.5	26.9	40.3	53.8	67.2	80.6	94.1	107.5	121.0
$2\frac{3}{8}$	15.0	30.0	44.9	60.0	74.9	89.9	104.8	119.8	134.8
$2\frac{1}{2}$	16.7	33.4	50.1	66.8	83.4	100.1	116.8	133.5	150.2
$2\frac{5}{8}$	18.8	36.6	54.9	73.2	91.5	109.8	128.1	146.3	164.6
$2\frac{3}{4}$	20.1	40.2	60.2	80.3	100.4	120.5	140.5	160.6	180.7
$2\frac{7}{8}$	21.9	43.9	65.8	87.8	109.7	131.7	153.6	175.6	197.5
3	23.9	47.8	71.7	95.6	119.4	143.3	167.2	191.1	215.0
$3\frac{1}{8}$	25.9	51.9	77.8	103.7	129.6	155.6	181.5	207.4	233.3
$3\frac{1}{4}$	28.0	56.1	84.1	112.2	140.2	168.2	196.3	224.3	253.4
$3\frac{3}{8}$	30.2	60.5	90.7	121.0	151.2	181.4	211.7	241.9	272.2
$3\frac{1}{2}$	32.5	65.0	97.5	130.0	162.6	195.1	227.6	260.1	292.6
$3\frac{5}{8}$	34.9	69.8	104.7	139.5	174.4	209.3	244.2	279.1	314.0
$3\frac{3}{4}$	37.3	74.7	112.0	149.3	186.7	224.0	261.3	298.7	336.0
$3\frac{7}{8}$	39.9	79.7	119.6	159.5	199.3	239.2	279.0	318.9	358.8
4	42.5	84.9	127.4	169.9	212.3	254.8	297.2	339.7	382.2
$4\frac{1}{8}$	45.2	90.3	135.5	180.7	225.9	271.0	316.2	361.4	406.6
$4\frac{1}{4}$	48.0	95.9	143.9	191.8	239.8	287.7	335.7	383.6	431.0
$4\frac{3}{8}$	50.8	101.6	152.4	203.3	254.1	304.9	355.7	406.5	457.3
$4\frac{1}{2}$	53.8	107.5	161.3	215.0	268.8	322.6	376.3	430.1	483.8
$4\frac{5}{8}$	56.8	113.6	170.4	227.2	283.9	340.7	397.5	454.3	511.1

ROUND IRON, — *Concluded.*

Size.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
$4\frac{3}{4}$	60.0	119.8	179.7	239.6	299.5	359.4	419.3	479.2	539.1
$4\frac{7}{8}$	63.1	126.2	189.3	252.4	315.5	378.6	441.7	504.8	567.8
5	66.8	133.5	200.3	267.0	333.8	400.5	467.3	534.0	600.8
$5\frac{1}{8}$	69.7	139.5	209.2	278.9	348.7	418.4	488.1	557.8	627.8
$5\frac{1}{4}$	73.2	146.3	219.5	292.7	365.9	439.0	512.2	585.4	658.5
$5\frac{3}{8}$	76.7	153.4	230.1	306.8	383.5	460.2	536.9	613.6	690.3
$5\frac{1}{2}$	80.3	160.6	240.9	321.2	401.5	481.8	562.1	642.4	722.7
$5\frac{5}{8}$	84.0	168.0	252.0	336.0	420.0	504.4	588.0	672.0	756.0
$5\frac{3}{4}$	87.8	175.6	263.3	351.1	438.9	526.7	614.4	702.2	790.0
$5\frac{7}{8}$	91.6	183.3	274.9	366.5	458.2	549.8	641.4	733.1	824.7
6	95.6	191.1	286.7	382.2	477.8	573.3	668.9	764.4	860.0
$6\frac{1}{4}$	103.7	207.4	311.1	414.8	518.5	622.2	725.9	829.6	933.3
$6\frac{1}{2}$	112.2	224.3	336.5	448.6	560.8	673.0	785.1	897.3	1009.4
$6\frac{3}{4}$	121.0	241.9	362.9	483.8	604.8	725.8	846.7	967.6	1088.6
7	130.0	260.1	390.1	520.2	650.2	780.3	910.3	1040.4	1170.4
$7\frac{1}{4}$	139.5	279.1	418.6	558.2	697.7	837.3	976.8	1116.4	1255.9
$7\frac{1}{2}$	149.3	298.7	448.0	597.3	741.6	896.0	1045.3	1194.6	1344.0
$7\frac{3}{4}$	159.5	318.9	478.4	637.8	797.3	956.7	1116.2	1275.6	1435.1
8	169.9	339.7	509.6	679.4	849.3	1019.1	1189.0	1358.8	1528.7
$8\frac{1}{4}$	180.7	361.4	542.1	722.8	903.5	1084.2	1264.9	1445.6	1626.3
$8\frac{1}{2}$	191.8	383.6	595.4	767.2	959.0	1150.8	1342.6	1534.5	1726.3
$8\frac{3}{4}$	203.3	406.5	609.8	813.0	1016.3	1219.6	1422.8	1626.1	1829.3
9	215.0	430.1	645.1	860.2	1075.2	1290.2	1505.3	1720.3	1935.4
$9\frac{1}{4}$	227.2	454.3	681.5	908.6	1135.8	1362.9	1590.1	1817.2	2044.4
$9\frac{1}{2}$	239.6	479.2	718.8	958.4	1198.0	1437.6	1677.2	1916.8	2156.4
$9\frac{3}{4}$	252.4	505.8	757.1	1009.5	1261.9	1514.3	1766.6	2019.0	2291.4
10	266.3	532.6	798.9	1065.2	1331.4	1597.7	1864.0	2130.3	2396.6
$10\frac{1}{4}$	278.9	557.8	836.8	1115.7	1394.6	1673.5	1952.5	2231.4	2510.3
$10\frac{1}{2}$	292.7	585.4	878.1	1170.8	1463.4	1756.1	2048.8	2341.5	2634.2
$10\frac{3}{4}$	306.8	603.6	920.4	1227.2	1534.0	1840.8	2147.6	2454.4	2761.2
11	321.2	642.4	963.6	1284.9	1606.1	1927.3	2248.5	2569.7	2890.9
$11\frac{1}{4}$	336.0	672.0	1008.0	1344.0	1680.0	2016.0	2352.0	2688.0	3024.0
$11\frac{1}{2}$	351.1	702.2	1053.3	1404.4	1755.5	2106.6	2457.7	2808.8	3159.9
$11\frac{3}{4}$	366.5	733.1	1099.6	1466.1	1832.7	2199.2	2565.8	2932.3	3298.8
12	382.2	764.4	1146.6	1528.8	1911.0	2293.2	2675.5	3057.7	3439.3

FLAT IRON.

Th'k.	Wid.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
¼	1	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6
¼	1¼	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5
¼	1½	1.3	2.5	3.8	5.1	6.3	7.6	8.9	10.1	11.4
¼	1¾	1.5	3.0	4.4	5.9	7.4	8.9	10.4	11.8	13.3
¼	2	1.7	3.4	5.1	6.8	8.5	10.1	11.8	13.5	15.2
¼	2¼	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1
¼	2½	2.1	4.2	6.3	8.4	10.6	12.7	14.8	16.9	19.0
¼	2¾	2.3	4.6	7.0	9.3	11.6	13.9	16.3	18.6	20.9
¼	3	2.5	5.1	7.6	10.1	12.7	15.2	17.7	20.3	22.8
¼	3¼	2.7	5.5	8.2	11.0	13.7	16.5	19.2	22.0	24.7
¼	3½	3.0	5.9	8.9	11.8	14.8	17.7	20.7	23.7	26.6
¼	3¾	3.2	6.3	9.5	12.7	15.8	19.0	22.2	25.4	28.5
¼	4	3.4	6.8	10.1	13.5	16.9	20.3	23.7	27.0	30.4
¼	4¼	3.6	7.2	10.8	14.4	18.0	21.5	25.1	28.7	32.3
¼	4½	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2
¼	4¾	4.0	8.0	12.0	16.1	20.1	24.1	28.1	32.1	36.1
¼	5	4.2	8.4	12.7	16.9	21.1	25.3	29.6	33.8	38.0
¼	5¼	4.4	8.9	13.3	17.7	22.2	26.6	31.1	35.5	39.9
¼	5½	4.6	9.3	13.9	18.6	23.2	27.9	32.5	37.2	41.8
¼	5¾	4.9	9.7	14.6	19.4	24.3	29.2	34.0	38.9	43.7
¼	6	5.1	10.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6
⅜	1	1.3	2.5	3.8	5.1	6.3	7.6	8.9	10.1	11.4
⅜	1¼	1.6	3.2	4.8	6.3	7.9	9.5	11.1	12.7	14.3
⅜	1½	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1
⅜	1¾	2.2	4.4	6.7	8.9	11.1	13.3	15.5	17.7	20.0
⅜	2	2.5	5.1	7.6	10.1	12.7	15.2	17.7	20.3	22.8
⅜	2¼	2.9	5.7	8.3	11.4	14.3	17.1	20.0	22.8	25.7
⅜	2½	3.2	6.3	9.5	12.7	15.8	19.0	22.2	25.4	28.5
⅜	2¾	3.5	7.0	10.5	13.9	17.4	20.9	24.4	27.9	31.4
⅜	3	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2
⅜	3¼	4.1	8.2	12.4	16.5	20.6	24.7	28.8	33.0	37.1
⅜	3½	4.4	8.9	13.3	17.7	22.2	26.6	31.1	35.5	39.9
⅜	3¾	4.8	9.5	14.3	19.0	23.8	28.5	33.3	38.0	42.8

FLAT IRON, — *Continued.*

Th'k.	Wid.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3/8	4	5.1	10.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6
3/8	4 1/4	5.4	10.8	16.1	21.5	26.9	32.3	37.7	43.1	48.5
3/8	4 1/2	5.7	11.4	17.1	22.8	28.5	34.2	39.9	45.6	51.3
3/8	4 3/4	6.0	12.0	18.1	24.1	30.1	36.1	42.1	48.2	54.2
3/8	5	6.3	12.7	19.0	25.3	31.7	38.0	44.4	50.7	57.0
3/8	5 1/4	6.7	13.3	20.0	26.6	33.3	39.9	46.6	53.2	59.9
3/8	5 1/2	7.0	13.9	20.9	27.9	34.9	41.8	48.8	55.8	62.7
3/8	5 3/4	7.3	14.6	21.9	29.2	36.4	43.7	51.0	58.3	65.7
3/8	6	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4
1/2	1	1.7	3.4	5.1	6.8	8.5	10.1	11.8	13.5	15.2
1/2	1 1/4	2.1	4.2	6.3	8.4	10.6	12.7	14.8	16.9	19.0
1/2	1 1/2	2.5	5.1	7.6	10.1	12.7	15.2	17.7	20.3	22.8
1/2	1 3/4	3.0	5.9	8.9	11.8	14.8	17.7	20.7	23.7	26.6
1/2	2	3.4	6.8	10.1	13.5	16.9	20.3	23.7	27.0	30.4
1/2	2 1/4	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2
1/2	2 1/2	4.2	8.4	12.7	16.9	21.1	25.3	29.6	33.8	38.0
1/2	2 3/4	4.6	9.3	13.9	18.6	23.2	27.9	32.5	37.2	41.8
1/2	3	5.1	10.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6
1/2	3 1/4	5.5	11.0	16.5	22.0	27.5	32.9	38.4	43.9	49.4
1/2	3 1/2	5.9	11.8	17.7	23.7	29.6	35.5	41.4	47.3	53.2
1/2	3 3/4	6.3	12.7	19.0	25.3	31.7	38.0	44.4	50.7	57.0
1/2	4	6.8	13.5	20.3	27.0	33.8	40.6	47.3	54.1	60.8
1/2	4 1/4	7.2	14.4	21.5	28.7	35.9	43.1	50.3	57.4	64.6
1/2	4 1/2	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4
1/2	4 3/4	8.0	16.1	24.1	32.1	40.1	48.2	56.2	64.2	72.2
1/2	5	8.4	16.9	25.3	33.8	42.2	50.7	59.1	67.6	76.0
1/2	5 1/4	8.9	17.7	26.6	35.5	44.4	53.2	62.1	71.0	79.9
1/2	5 1/2	9.3	18.6	27.9	37.2	46.5	55.8	65.1	74.4	83.7
1/2	5 3/4	9.7	19.4	29.2	38.9	48.6	58.3	68.0	77.7	87.5
1/2	6	10.1	20.3	30.4	40.6	50.7	60.8	70.9	81.1	91.2
5/8	1	2.1	4.2	6.3	8.4	10.6	12.7	14.8	16.9	19.0
5/8	1 1/4	2.6	5.3	7.9	10.6	13.2	15.8	18.5	21.1	23.8

FLAT IRON, — *Continued.*

Th'k.	Wid.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
⅝	1½	3.2	6.3	9.5	12.7	15.8	19.0	22.2	25.4	28.5
⅝	1¾	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33.3
⅝	2	4.2	8.4	12.7	16.9	21.1	25.3	29.9	33.8	38.0
⅝	2¼	4.8	9.5	14.3	19.0	23.8	28.5	33.3	38.0	42.8
⅝	2½	5.3	10.6	15.8	21.1	26.4	31.7	37.0	42.2	47.5
⅝	2¾	5.8	11.6	17.4	23.2	29.0	34.8	40.7	46.5	52.3
⅝	3	6.3	12.7	19.0	25.3	31.7	38.0	44.4	50.7	57.6
⅝	3¼	6.9	13.7	20.6	27.5	34.3	41.2	48.1	54.9	61.8
⅝	3½	7.4	14.8	22.2	29.6	37.0	44.4	51.8	59.2	66.5
⅝	3¾	7.9	15.8	23.8	31.7	39.6	47.5	55.5	63.4	71.3
⅝	4	8.4	16.9	25.3	33.8	42.2	50.7	59.1	67.6	76.0
⅝	4¼	9.0	18.0	26.9	35.9	44.9	53.9	62.9	71.8	80.8
⅝	4½	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.1	85.6
⅝	4¾	10.0	20.1	30.1	40.1	50.2	60.2	70.2	80.3	90.3
⅝	5	10.6	21.1	31.7	42.3	52.8	63.4	73.9	84.5	95.1
⅝	5¼	11.1	22.2	33.3	44.4	55.5	66.5	77.6	88.7	99.8
⅝	5½	11.6	23.2	34.9	46.5	58.1	69.7	81.3	92.9	104.6
⅝	5¾	12.1	24.3	36.4	48.5	60.7	72.9	85.0	97.2	109.3
⅝	6	12.7	25.3	38.0	50.7	63.4	76.0	88.7	101.4	114.1
¾	1	2.5	5.1	7.6	10.1	12.7	15.2	17.7	20.3	22.8
¾	1¼	3.2	6.3	9.5	12.7	15.8	19.0	22.2	25.4	28.5
¾	1½	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2
¾	1¾	4.4	8.0	13.3	17.7	22.2	26.6	31.1	35.5	39.9
¾	2	5.1	10.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6
¾	2¼	5.7	11.4	17.1	22.8	28.5	34.2	39.9	45.6	51.3
¾	2½	6.3	12.7	19.0	25.3	31.7	38.0	44.4	50.7	57.0
¾	2¾	7.0	13.9	20.9	27.9	34.9	41.8	48.8	55.8	62.7
¾	3	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.9	68.4
¾	3¼	8.2	16.5	24.7	33.0	41.2	49.4	57.7	65.9	74.2
¾	3½	8.9	17.7	26.6	35.5	44.4	53.2	62.1	71.0	79.9
¾	3¾	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.1	85.6
¾	4	10.1	20.3	30.4	40.6	50.7	68.0	70.9	81.1	91.2

FLAT IRON, — *Concluded.*

Th'k.	Wid.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.
Inch.	Inch.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
¾	4¼	10.8	21.5	32.3	43.1	53.9	64.6	75.4	86.2	97.0
¾	4½	11.4	22.8	34.2	45.6	57.0	68.4	79.9	91.3	102.7
¾	4¾	12.0	24.1	36.1	48.2	60.2	72.2	84.3	96.3	108.4
¾	5	12.7	25.3	38.0	50.7	63.4	76.0	88.7	101.4	114.0
¾	5¼	13.3	26.6	39.9	53.2	66.5	79.8	93.1	106.5	119.8
¾	5½	13.9	27.9	41.8	55.8	69.7	83.7	97.6	111.5	125.5
¾	5¾	14.6	29.1	43.7	58.3	72.9	87.4	102.0	116.6	131.2
¾	6	15.2	30.4	45.6	60.8	76.0	91.2	106.5	121.7	136.9
1	1½	5.1	10.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6
1	2	6.8	13.5	20.3	27.0	33.8	40.6	47.8	54.1	60.8
1	3	10.1	20.3	30.4	40.6	50.7	60.8	70.9	81.1	91.2
1	4	13.5	27.0	40.6	54.1	67.6	81.1	94.6	108.1	121.7
1	5	16.9	33.8	50.7	67.6	84.5	101.4	118.3	135.2	152.1
1	6	20.3	40.6	60.8	81.1	101.4	121.7	141.9	162.2	182.5

The following table shows the weight of a square foot of different metal plates of thicknesses from $\frac{1}{16}''$ to $1''$, advancing by $\frac{1}{16}''$.

METAL PLATES.

16ths.	Wrought Iron.	Cast Iron.	Cast Copper.	Cast Brass.	Cast Lead.	Cast Zinc.	Cast Tin.	Cast Silver.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	2.5	2.3	2.9	2.7	3.7	2.3	2.4	3.4
2	5.1	4.7	5.7	5.5	7.4	4.7	4.7	6.8
3	7.6	7.0	8.6	8.2	11.1	7.0	7.1	10.2
4	10.1	9.4	11.4	11.0	14.8	9.4	9.5	13.6
5	12.7	11.7	14.3	13.7	18.5	11.7	11.9	17.0
6	15.2	14.0	17.2	16.4	22.2	14.0	14.2	20.5
7	17.9	16.4	20.0	19.2	25.9	16.4	16.6	23.9

METAL PLATES, — *Concluded.*

16ths.	Wrought Iron.	Cast Iron.	Cast Copper.	Cast Brass.	Cast Lead.	Cast Zinc.	Cast Tin.	Cast Silver.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
8	20.3	18.8	22.9	21.9	29.5	18.7	19.0	27.3
9	22.8	21.1	25.7	24.6	33.2	21.1	21.4	30.7
10	25.4	23.5	28.6	27.4	36.9	23.4	23.7	34.1
11	27.9	25.8	31.4	30.1	40.6	25.7	26.1	37.5
12	30.4	28.1	34.3	32.9	44.3	28.1	28.5	40.9
13	32.9	30.5	37.2	35.6	48.0	30.4	30.9	44.3
14	35.5	32.9	40.0	38.3	51.7	32.8	33.2	47.7
15	38.0	35.2	42.9	41.2	55.4	35.1	35.6	51.1
16	40.6	37.6	45.8	43.9	59.1	37.5	38.0	54.6

WEIGHT OF SOLID CYLINDERS OF CAST-IRON,

12″ long, in pounds avoirdupois.

Diam. Inches.	Weight in pounds.	Diam. Inches.	Weight in pounds.	Diam. Inches.	Weight in pounds.	Diam. Inches.	Weight in pounds.
$\frac{3}{4}$	1.394	$2\frac{1}{2}$	15.492	$4\frac{1}{2}$	50.193	8	158.638
$\frac{7}{8}$	1.897	$2\frac{5}{8}$	17.080	$4\frac{3}{4}$	55.926	$8\frac{1}{2}$	179.087
1	2.478	$2\frac{3}{4}$	18.745	5	61.968	9	200.774
$1\frac{1}{8}$	3.137	$2\frac{7}{8}$	20.488	$5\frac{1}{4}$	68.319	$9\frac{1}{2}$	223.704
$1\frac{1}{4}$	3.873	3	22.308	$5\frac{1}{2}$	74.981	10	247.872
$1\frac{3}{8}$	4.686	$3\frac{1}{8}$	24.206	$5\frac{3}{4}$	81.952	$10\frac{1}{2}$	273.278
$1\frac{1}{2}$	5.577	$3\frac{1}{4}$	26.181	6	89.234	11	299.925
$1\frac{5}{8}$	6.545	$3\frac{3}{8}$	28.234	$6\frac{1}{4}$	96.825	$11\frac{1}{2}$	327.811
$1\frac{3}{4}$	7.591	$3\frac{1}{2}$	30.364	$6\frac{1}{2}$	104.726	12	356.935
$1\frac{7}{8}$	8.714	$3\frac{5}{8}$	32.572	$6\frac{3}{4}$	112.936	13	418.903
2	9.915	$3\frac{3}{4}$	34.857	7	121.457	14	485.830
$2\frac{1}{8}$	11.193	$3\frac{7}{8}$	37.219	$7\frac{1}{4}$	130.287	15	557.712
$2\frac{1}{4}$	12.548	4	39.660	$7\frac{1}{2}$	139.428	16	634.552
$2\frac{3}{8}$	13.981	$4\frac{1}{4}$	44.771	$7\frac{3}{4}$	148.878		

Cubic inches of cast-iron multiplied by .263 = pounds avoirdupois. Circular inches of cast-iron multiplied by .2065 = pounds avoirdupois.

A TABLE CONTAINING THE CIRCUMFERENCES AND AREAS OF CIRCLES,

From 1 to 50 ft., advancing by an inch; also the side of a square of equal area, and the contents of each in imperial gallons and cubic yards, at 1 ft. in depth.

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
1′	3′ 1⅝″	.7854	10⅝″	4.8946	.0291
1″	3′ 4⅝″	.9217	11½″	5.7440	.0341
2″	3′ 8″	1.0690	1′ ⅜″	6.6620	.0395
3″	3′ 11″	1.2271	1′ 1¼″	7.6472	.0454
4″	4′ 2⅛″	1.3962	1′ 2⅛″	8.7011	.0517
5″	4′ 5⅜″	1.5761	1′ 3″	9.8222	.0583
6″	4′ 8½″	1.7671	1′ 3⅞″	11.0125	.0654
7″	4′ 11⅝″	1.9689	1′ 4¾″	12.2701	.0729
8″	5′ 2¾″	2.1816	1′ 5⅜″	13.5957	.0808
9″	5′ 5⅞″	2.4052	1′ 6½″	14.9892	.0890
10″	5′ 9″	2.6398	1′ 7½″	16.4512	.0977
11″	6′ 2¼″	2.8852	1′ 8⅜″	17.9025	.1068
2′	6′ 3⅜″	3.1416	1′ 9¼″	19.5784	.1163
1″	6′ 6½″	3.4087	1′ 10⅛″	21.2430	.1262
2″	6′ 9⅝″	3.6869	1′ 11″	22.9767	.1365
3″	7′ 10¾″	3.9760	1′ 11⅞″	24.7784	.1472
4″	7′ 3⅞″	4.2760	2′ ¾″	27.2480	.1583
5″	7′ 7½″	4.5869	2′ 1⅝″	28.5855	.1698
6″	7′ 10¼″	4.9087	2′ 2½″	30.5910	.1818
7″	8′ 1⅜″	5.2413	2′ 3⅜″	32.6637	.1941
8″	8′ 4½″	5.5850	2′ 4¼″	34.8057	.2068
9″	8′ 7⅝″	5.9395	2′ 5¼″	37.0149	.2199
10″	8′ 10¾″	6.3049	2′ 6⅛″	39.2921	.2335
11″	9′ 1⅞″	6.6813	2′ 7″	41.6378	.2474
3′	9′ 5″	7.0686	2′ 7⅞″	44.0515	.2618
1″	9′ 8¼″	7.4666	2′ 8¾″	46.5318	.2765
2″	9′ 11¾″	7.8757	2′ 9⅝″	49.0813	.2916
3″	10′ 2½″	8.2957	2′ 10¼″	51.6988	.3072
4″	10′ 5⅝″	8.7265	2′ 11⅜″	54.3835	.3232
5″	10′ 8¾″	9.1683	3′ ¼″	57.0994	.3395
6″	10′ 11⅞″	9.6211	3′ 1⅛″	60.9587	.3565

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	11′ 3″	10.0846	3′ 2″	62.8472	.3733
8″	11′ 6⅛″	10.5591	3′ 3″	65.8043	.3911
9″	11′ 9⅜″	11.0446	3′ 3⅞″	68.8299	.4090
10″	12′ 5½″	11.5409	3′ 4¾″	71.9228	.4274
11″	12′ 3⅝″	12.0481	3′ 5⅝″	75.0837	.4462
4′	12′ 6¾″	12.5664	3′ 6½″	78.3128	.4654
1″	12′ 9⅞″	13.0952	3′ 7⅜″	81.6092	.4851
2″	13′ 1″	13.6353	3′ 8¼″	84.9751	.5050
3″	13′ 4⅛″	14.1862	3′ 9⅛″	85.8583	.5254
4″	13′ 7¼″	14.7479	3′ 10″	91.9089	.5462
5″	13′ 10½″	15.3206	3′ 10⅞″	95.4779	.5674
6″	14′ 1⅝″	15.9043	3′ 11⅞″	99.1155	.5893
7″	14′ 4⅝″	16.4986	4′ ¾″	102.8192	.6111
8″	14′ 7⅞″	17.1041	4′ 1⅝″	106.5927	.6334
9″	14′ 11″	17.7205	4′ 2½″	110.4341	.6563
10″	15′ 2⅛″	18.3476	4′ 3⅜″	114.3421	.6795
11″	15′ 5¼″	18.9858	4′ 4¼″	118.3818	.7032
5′	15′ 8½″	19.6350	4′ 5⅛″	122.3653	.7272
1″	15′ 11⅝″	20.2947	4′ 6″	126.4765	.7516
2″	16′ 2¾″	20.9656	4′ 6⅞″	130.6576	.7764
3″	16′ 5¾″	21.6475	4′ 7¾″	134.9072	.8017
4″	16′ 9″	22.3400	4′ 8⅝″	139.2228	.8275
5″	17′ ⅛″	23.0437	4′ 9⅝″	143.6083	.8534
6″	17′ 3¼″	23.7583	4′ 10½″	148.0617	.8800
7″	17′ 6⅜″	24.4835	4′ 11⅜″	152.5811	.9071
8″	17′ 9⅝″	25.2199	5′ ¼″	157.1704	.9340
9″	18′ ¾″	25.9672	5′ 1⅛″	161.8275	.9617
10″	18′ 3⅞″	26.7251	5′ 2″	166.5508	.9897
11″	18′ 7⅛″	27.4943	5′ 2⅞″	171.3444	1.0184
6′	18′ 10⅛″	28.2744	5′ 3¾″	176.2060	1.0472
1″	19′ 1¼″	29.0649	5′ 4⅝″	181.1324	1.0764
2″	19′ 4⅜″	29.8668	5′ 5½″	185.1298	1.1042
3″	19′ 7½″	30.6796	5′ 6⅜″	191.1952	1.1363
4″	19′ 10⅝″	31.5029	5′ 7⅜″	196.3320	1.1667
5″	20′ 1⅞″	32.3376	5′ 8¼″	201.5279	1.1976
6″	20′ 4⅞″	33.1831	5′ 9⅛″	206.7970	1.2290

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	20′ 8⅛″	34.0391	5′ 10″	212.1376	1.2607
8″	20′ 11½″	34.9065	5′ 10⅞″	217.5373	1.2928
9″	21′ 2⅜″	35.7847	5′ 11¾″	223.0102	1.3253
10″	21′ 5½″	36.6735	6′ ⅝″	228.4492	1.3582
11″	21′ 8¾″	37.5736	6′ 1½″	234.1586	1.3926
7′	21′ 11⅞″	38.4846	6′ 2⅜″	239.8360	1.4254
1″	22′ 3″	39.4060	6′ 3¼″	245.5781	1.4602
2″	22′ 6⅛″	40.3388	6′ 4⅛″	251.3914	1.4940
3″	22′ 9¼″	41.2825	6′ 5⅛″	257.2725	1.5300
4″	23′ ⅜″	42.2367	6′ 6″	263.2191	1.5643
5″	23′ 2⅛″	43.2022	6′ 6⅞″	269.2361	1.6001
6″	23′ 6¾″	44.1787	6′ 7¾″	275.3216	1.6361
7″	23′ 11″	45.1656	6′ 8⅝″	281.4720	1.6728
8″	24′ 1⅛″	46.1638	6′ 9½″	287.6928	1.7098
9″	24′ 4⅛″	47.1730	6′ 10⅜″	293.9721	1.7471
10″	24′ 7¼″	48.1926	6′ 11¼″	300.3362	1.7849
11″	24′ 10⅜″	49.2236	7′ 0″	306.7614	1.8231
8′	25′ 1½″	50.2656	7′ ⅛″	313.2552	1.8617
1″	25′ 4⅝″	51.3178	7′ 1¾″	319.8125	1.9007
2″	25′ 7⅞″	52.3816	7′ 2⅞″	326.4421	1.9394
3″	25′ 11″	53.4562	7′ 3¾″	333.1390	1.9800
4″	26′ 2⅛″	54.5412	7′ 4⅝″	339.9007	2.0201
5″	26′ 5¼″	55.6377	7′ 5½″	346.7341	2.0607
6″	26′ 8⅜″	56.7451	7′ 6⅜″	353.6354	2.1017
7″	26′ 11½″	57.8628	7′ 7¼″	360.6009	2.1430
8″	27′ 2¾″	58.9920	7′ 8⅛″	367.6381	2.1850
9″	27′ 5¾″	60.1321	7′ 9⅛″	374.3432	2.2698
10″	27′ 9″	61.2826	7′ 9⅞″	381.9031	2.3128
11″	28′ ⅛″	62.4445	7′ 10¾″	389.1541	2.4001
9′	28′ 3¼″	63.6174	7′ 11⅝″	396.4636	2.3562
1″	28′ 6⅜″	64.8006	8′ ½″	403.8373	2.4000
2″	28′ 9½″	65.9951	8′ 1½″	411.2814	2.4443
3″	29′ ⅝″	67.2007	8′ 2⅜″	418.7947	2.4889
4″	29′ 3¾″	68.4166	8′ 3¼″	426.3722	2.5339
5″	29′ 7″	69.6440	8′ 4⅛″	434.0214	2.5795
6″	29′ 10⅛″	70.8823	8′ 5″	441.7384	2.6263

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	30′ 1¼″	72.1309	8′ 5⅞″	449.5197	2.6715
8″	30′ 4⅜″	73.3910	8′ 6¾″	457.3727	2.7183
9″	30′ 7½″	74.6620	8′ 7⅝″	465.2935	2.7653
10″	30′ 11⅝″	75.9433	8′ 8½″	473.2786	2.8128
11″	31′ 1¾″	77.2362	8′ 9½″	481.3359	2.8607
10′	31′ 5″	78.5400	8′ 10¼″	489.4612	2.9089
1″	31′ 8⅛″	79.8541	8′ 11¼″	497.6501	2.9575
2″	31′ 11¼″	81.1795	9′ ⅛″	505.9106	3.0066
3″	32′ 2⅜″	82.5160	9′ 1″	514.2397	3.0561
4″	32′ 5½″	83.8627	9′ 1⅞″	522.6323	3.1060
5″	32′ 8⅝″	85.2211	9′ 2¾″	530.9978	3.1563
6″	32′ 11¾″	86.5903	9′ 3⅝″	539.6307	3.2070
7″	33′ 2⅞″	87.9697	9′ 4½″	548.2271	3.2211
8″	33′ 6⅛″	89.3608	9′ 5⅜″	556.8965	3.3096
9″	33′ 9¼″	90.7627	9′ 6¼″	565.2331	3.3615
10″	34′ ⅜″	92.1749	9′ 7¼″	574.4339	3.4138
11″	34′ 3½″	93.5986	9′ 8⅛″	583.3064	3.4665
11′	34′ 6⅝″	95.0334	9′ 8⅞″	592.2481	3.5197
1″	34′ 9¾″	96.4783	9′ 9⅞″	601.2529	3.5733
2″	35′ ⅞″	97.9347	9′ 10¾″	610.3290	3.6272
3″	35′ 4⅛″	99.4021	9′ 11⅝″	619.4738	3.6815
4″	35′ 7¼″	100.8797	10′ ½″	628.0822	3.7362
5″	35′ 10⅝″	102.3689	10′ 1⅜″	637.9629	3.7914
6″	36′ 1½″	103.8691	10′ 2¼″	647.3122	3.8470
7″	36′ 4½″	105.3794	10′ 3⅛″	656.7244	3.9029
8″	36′ 7¾″	106.9013	10′ 4″	666.2089	3.9593
9″	36′ 10⅞″	108.4342	10′ 5″	675.7619	4.0160
10″	37′ 2¾″	109.9772	10′ 5⅞″	685.3779	4.0732
11″	37′ 5¼″	111.5319	10′ 6¾″	695.0668	4.1308
12′	37′ 8⅜″	113.0976	10′ 7⅝″	706.8242	4.1888
1″	37′ 11½″	114.6732	10′ 8½″	714.6433	4.2471
2″	38′ 2⅝″	116.2607	10′ 9⅜″	724.5366	4.3059
3″	38′ 5¾″	117.8590	10′ 10¼″	734.4972	4.3651
4″	38′ 8⅞″	119.4674	10′ 11⅛″	744.5208	4.4241
5″	39′ 0″	121.0876	11′ 0″	754.6179	4.4847
6″	39′ 3¼″	122.7187	11′ ⅞″	764.7829	4.5451

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	39′ 6⅜″	124.3598	11′ 1⅞″	775.0102	4.6059
8″	39′ 9½″	126.0127	11′ 2⅝″	785.3111	4.6671
9″	40′ ⅝″	127.6765	11′ 3⅝″	795.6799	4.7287
10″	40′ 3¾″	129.3504	11′ 4½″	806.1116	4.7907
11″	40′ 6⅞″	131.0360	11′ 5⅜″	816.6163	4.8531
13′	40′ 10″	132.7326	11′ 6¼″	827.1895	4.9160
1″	41′ 1⅛″	134.4391	11′ 7⅛″	837.8244	4.9792
2″	41′ 4⅜″	136.1574	11′ 8⅛″	848.5329	5.0428
3″	41′ 7½″	137.8867	11′ 8⅞″	859.3099	5.1106
4″	41′ 10⅝″	139.6260	11′ 9¾″	870.1492	5.1713
5″	42′ 1⅝″	141.3771	11′ 10⅝″	881.0620	5.2361
6″	42′ 4⅞″	143.1391	11′ 11⅝″	892.0428	5.3014
7″	42′ 8″	144.9111	12′ ½″	907.0859	5.3670
8″	42′ 11⅛″	146.6949	12′ 1⅜″	914.2026	5.4331
9″	43′ 2¼″	148.4896	12′ 2¼″	923.3871	5.4996
10″	43′ 5½″	150.2943	12′ 3⅛″	936.6340	5.5653
11″	43′ 8⅝″	152.1109	12′ 4″	947.9551	5.6337
14′	43′ 11¾″	153.9384	12′ 4⅞″	959.3441	5.7014
1″	44′ 2⅞″	155.7758	12′ 5⅝″	970.7947	5.7694
2″	44′ 6″	157.6250	12′ 6½″	982.3190	5.8369
3″	44′ 9⅛″	159.4852	12′ 7½″	993.9117	5.9069
4″	45′ ¼″	161.3553	12′ 8⅜″	1005.5662	5.9761
5″	45′ 3½″	163.2373	12′ 9⅜″	1017.2958	6.0458
6″	45′ 6⅝″	165.1303	12′ 10¼″	1029.0920	6.1159
7″	45′ 9¾″	167.0331	12′ 11⅛″	1040.9502	6.1864
8″	46′ ⅞″	168.9479	13′ 0″	1052.8733	6.2573
9″	46′ 4″	170.8735	13′ 1⅛″	1064.8846	6.3286
10″	46′ 7⅛″	172.8091	13′ 1¾″	1076.9462	6.4410
11″	46′ 11¼″	174.7565	13′ 2⅝″	1089.0825	6.4724
15′	47′ 1½″	176.7150	13′ 3½″	1101.2875	6.5450
1″	47′ 4⅝″	178.6832	13′ 4⅜″	1113.4537	6.6178
2″	47′ 7¾″	180.6634	13′ 5¼″	1125.8943	6.6912
3″	47′ 10⅞″	182.6545	13′ 6⅛″	1138.3028	6.7649
4″	48′ 2½″	184.6555	13′ 7⅛″	1149.7730	6.8390
5″	48′ 5⅛″	186.6684	13′ 8″	1163.3174	6.9126
6″	48′ 8¼″	188.6923	13′ 8⅞″	1172.9304	6.9886

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	48′ 11⅜″	190.7260	13′ 9¾″	1188.6054	7.0639
8″	49′ 2⅝″	192.7716	13′ 10⅝″	1201.3626	7.1396
9″	49′ 5¾″	194.8282	13′ 11½″	1214.1693	7.2158
10″	49′ 8⅞″	196.8946	14′ ⅜″	1227.0471	7.2923
11″	50′ 0″	198.9730	14′ 1¼″	1236.9997	7.3693
16′	50′ 3⅛″	201.0624	14′ 2⅛″	1253.0208	7.4467
1″	50′ 6¼″	203.1615	14′ 3″	1266.1023	7.5245
2″	50′ 9⅝″	205.2726	14′ 3⅞″	1279.2588	7.6026
3″	51′ ½″	207.3946	14′ 4⅞″	1292.4831	7.6812
4″	51′ 3¾″	209.5264	14′ 5¾″	1306.7685	7.7602
5″	51′ 6½″	211.6703	14′ 6⅝″	1309.1293	7.8396
6″	51′ 10″	213.8251	14′ 7½″	1332.5580	7.9194
7″	52′ 1⅛″	215.9896	14′ 8⅜″	1346.0471	7.9996
8″	52′ 4¼″	218.1662	14′ 9¼″	1359.6138	8.0802
9″	52′ 7⅜″	220.3537	14′ 10¼″	1379.2442	8.1612
10″	52′ 10½″	222.5510	14′ 11″	1386.9378	8.2426
11″	53′ 1⅝″	224.7603	14′ 11⅞″	1400.7061	8.3444
17′	53′ 4⅞″	226.9806	15′ ¾″	1414.5430	8.4067
1″	53′ 8″	229.2105	15′ 1⅝″	1428.4398	8.4890
2″	53′ 11⅛″	231.4525	15′ 2⅝″	1442.4119	8.5352
3″	54′ 2⅛″	233.7055	15′ 3½″	1456.4526	8.6557
4″	54′ 5⅜″	235.9682	15′ 4⅜″	1470.5538	8.7395
5″	54′ 8½″	238.2430	15′ 5¼″	1484.6303	8.8238
6″	54′ 11⅝″	240.5287	15′ 6⅛″	1498.9748	8.9081
7″	55′ 2⅞″	242.8241	15′ 7″	1513.2792	8.9234
8″	55′ 6″	245.1316	15′ 7⅞″	1527.6601	9.0789
9″	55′ 9⅛″	247.4500	15′ 8¾″	1542.1084	9.1642
10″	56′ ¼″	249.7781	15′ 9⅝″	1566.6171	9.2510
11″	56′ 3½″	252.1184	15′ 10½″	1571.2018	9.3377
18′	56′ 6½″	254.4696	15′ 11⅜″	1585.8545	9.4248
1″	56′ 9⅝″	256.8303	16′ ⅜″	1600.5664	9.5122
2″	57′ ⅞″	259.2033	16′ 1¼″	1615.3549	9.6000
3″	57′ 4″	261.5872	16′ 2⅛″	1630.2114	9.6884
4″	57′ 7⅛″	263.9807	16′ 3⅛″	1645.1277	9.7252
5″	57′ 10¼″	266.3864	16′ 3⅞″	1660.1200	9.8661
6″	58′ 1⅜″	268.8031	16′ 4¾″	1675.1809	9.9556

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	58′ 4½″	271.2293	16′ 5⅝″	1690.3009	10.0451
8″	58′ 7⅝″	273.6678	16′ 6½″	1705.4977	10.1358
9″	58′ 10¾″	276.1171	16′ 7⅜″	1720.7617	10.2264
10″	59′ 2″	278.5761	16′ 8¼″	1736.0862	10.3176
11″	59′ 5⅛″	281.0472	16′ 9¼″	1751.4861	10.4091
19′	59′ 8¼″	283.5294	16′ 10″	1766.9552	10.5011
1″	59′ 11½″	286.0210	16′ 11″	1782.4828	10.5933
2″	60′ 2½″	288.5249	16′ 11⅞″	1799.0871	10.6861
3″	60′ 5⅝″	291.0397	17′ ¾″	1813.7594	10.7792
4″	60′ 8¾″	293.5641	17′ 1⅝″	1829.4914	10.8727
5″	60′ 11⅞″	296.1107	17′ 2½″	1845.3005	10.9665
6″	61′ 3⅛″	298.6843	17′ 3⅜″	1861.0762	11.0610
7″	61′ 6¼″	301.2054	17′ 4¼″	1877.1120	11.1668
8″	61′ 9½″	303.7747	17′ 5⅛″	1893.1239	11.2509
9″	62′ ½″	306.3550	17′ 6″	1909.2043	11.3464
10″	62′ 3⅝″	308.9448	17′ 7″	1925.3439	11.4424
11″	62′ 6¾″	311.5469	17′ 7⅞″	1941.5602	11.5384
20′	62′ 9⅞″	314.1600	17′ 8⅝″	1957.8451	11.6355
1″	63′ 1⅛″	316.7824	17′ 9⅝″	1974.1879	11.7326
2″	63′ 4¼″	319.4173	17′ 10½″	1990.6086	11.8302
3″	63′ 7⅜″	322.0630	17′ 11⅜″	2007.0966	11.9282
4″	63′ 11½″	324.7182	18′ ¼″	2023.6438	12.0266
5″	64′ 1⅝″	327.3858	18′ 1⅛″	2040.2683	12.1254
6″	64′ 4¾″	330.0643	18′ 2″	2056.9607	12.2246
7″	64′ 7⅞″	332.7522	18′ 2⅞″	2073.7117	12.3241
8″	64′ 11″	335.4525	18′ 3¾″	2090.5399	12.4241
9″	65′ 2¼″	338.1637	18′ 4¾″	2107.4361	12.5245
10″	65′ 5⅜″	340.8844	18′ 5⅝″	2124.3915	12.6253
11″	65′ 8¼″	343.6174	18′ 6½″	2141.4236	12.7265
21′	65′ 11⅝″	346.3614	18′ 7¼″	2158.5242	12.8282
1″	66′ 2¾″	349.1147	18′ 8¼″	2175.6828	12.9301
2″	66′ 5⅞″	351.8804	18′ 9⅛″	2192.9186	13.0326
3″	66′ 9″	354.6571	18′ 10″	2210.2110	13.1354
4″	66′ ⅛″	357.4432	18′ 10⅞″	2227.5860	13.2386
5″	67′ 3⅜″	360.2417	18′ 11¾″	2245.0362	13.3422
6″	67′ 6½″	363.0511	19′ ⅝″	2262.5344	13.4463

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	67′ 9⅝″	365.8698	19′ 1⅝″	2280.1004	13.5507
8″	68′ ¾″	368.7011	19′ 2½″	2297.7452	13.6555
9″	68′ 3⅞″	371.5432	19′ 3⅜″	2315.4572	13.7608
10″	68′ 7″	374.3947	19′ 4¼″	2333.2277	13.8664
11″	68′ 10¼″	377.2587	19′ 5⅛″	2351.0762	13.9725
22′	69′ 1⅜″	380.1336	19′ 5⅞″	2368.9925	14.0800
1″	69′ 4½″	383.0177	19′ 6⅞″	2386.9663	14.1858
2″	69′ 7⅝″	385.9144	19′ 7¾″	2405.0185	14.2931
3″	69′ 10¾″	388.8220	19′ 8⅝″	2423.1387	14.4008
4″	70′ 1⅞″	391.7389	19′ 9½″	2441.3168	14.5088
5″	70′ 5″	394.6683	19′ 10⅜″	2458.5728	14.6173
6″	70′ 8¼″	397.6087	19′ 11⅜″	2477.9074	14.7262
7″	70′ 11⅛″	400.5583	20′ ¼″	2496.2793	14.8354
8″	71′ 2½″	403.5204	20′ 1⅛″	2514.7391	14.9452
9″	71′ 5⅝″	406.4935	20′ 2″	2533.2674	15.0558
10″	71′ 8¾″	409.4759	20′ 2⅞″	2551.8538	15.1657
11″	71′ 11⅞″	412.4707	20′ 3¾″	2570.5174	15.2766
23′	72′ 3″	415.4766	20′ 4½″	2589.2501	15.3880
1″	72′ 6⅛″	418.4915	20′ 5½″	2607.9390	15.4996
2″	72′ 9⅜″	421.5192	20′ 6¾″	2626.9076	15.6118
3″	73′ ½″	424.5577	20′ 7¼″	2645.8435	15.7243
4″	73′ 3⅝″	427.6055	20′ 8⅛″	2664.8374	15.8372
5″	73′ 6¾″	430.6658	20′ 9⅛″	2683.9092	15.9505
6″	73′ 9⅞″	433.7371	20′ 10″	2703.0496	16.0643
7″	74′ 1″	436.8175	20′ 10⅞″	2722.2466	16.1784
8″	74′ 4⅛″	439.9106	20′ 11⅜″	2741.5228	16.2929
9″	74′ 7¼″	443.0146	21′ ⅝″	2760.8669	16.4079
10″	74′ 10⅝″	446.1278	21′ 1½″	2780.2684	16.5232
11″	75′ 1⅝″	449.2536	21′ 2⅜″	2799.7484	16.6390
24′	75′ 4¾″	452.3904	21′ 3¼″	2819.2969	16.7556
1″	75′ 7⅞″	455.5362	21′ 4⅛″	2838.9015	16.8717
2″	75′ 11″	458.6948	21′ 5″	2858.5859	16.9886
3″	76′ 2⅛″	461.8642	21′ 6″	2878.3376	17.1060
4″	76′ 5¼″	465.0428	21′ 6⅞″	2898.1467	17.2608
5″	76′ 8½″	468.2341	21′ 7¾″	2918.0349	17.3420
6″	76′ 11⅝″	471.4363	21′ 8⅝″	2937.9941	17.4606

CIRCUMFERENCES AND AREAS OF CIRCLES,—*Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	77′ 2¾″	474.6476	21′ 9½″	2958.0038	17.5795
8″	77′ 5⅞″	477.8716	21′ 10⅜″	2978.0958	17.6989
9″	77′ 9″	481.1065	21′ 11¼″	2998.2557	17.8187
10″	78′ ⅛″	484.3506	22′ ⅛″	3018.4729	17.9389
11″	78′ 3¼″	487.6073	22′ 1″	3038.8686	18.3019
25′	78′ 6⅜″	490.8750	22′ 1⅞″	3059.1330	18.1805
1″	78′ 9½″	494.1516	22′ 2¾″	3079.5527	18.2385
2″	79′ ¾″	497.4411	22′ 3¾″	3100.0529	18.4237
3″	79′ 3⅞″	500.7415	22′ 4⅝″	3120.6210	18.6687
4″	79′ 7⅛″	504.0510	22′ 6½″	3141.2458	18.7196
5″	79′ 11⅛″	507.3732	22′ 6⅜″	3161.9497	18.7916
6″	80′ 1¼″	510.7063	22′ 7¼″	3182.7214	18.9150
7″	80′ 4⅜″	514.0484	22′ 8⅛″	3203.5496	19.0388
8″	80′ 7⅝″	517.4034	22′ 9″	3224.4579	19.1630
9″	80′ 10¾″	520.7692	22′ 9⅞″	3245.4336	19.2877
10″	81′ 1⅞″	524.1441	22′ 10¾″	3266.4860	19.4127
11″	81′ 5″	527.5318	22′ 11⅝″	3287.6381	19.5382
26′	81′ 8⅛″	530.9304	23′ ½″	3308.7582	19.6640
1″	81′ 11¼″	534.3379	23′ 1½″	3329.9937	19.7902
2″	82′ 2⅜″	537.7583	23′ 2⅜″	3351.3097	19.9169
3″	82′ 5¼″	541.1896	23′ 3¼″	3372.6935	20.0440
4″	82′ 8⅝″	544.6299	23′ 4⅛″	3394.1535	20.1714
5″	82′ 11⅞″	548.0830	23′ 5″	3415.6532	20.2993
6″	83′ 3″	551.5471	23′ 5⅞″	3437.2415	20.4276
7″	83′ 6⅛″	555.0201	23′ 6¾″	3458.8852	20.5562
8″	83′ 9¼″	558.5059	23′ 7⅝″	3480.6087	20.6854
9″	84′ ⅜″	562.0027	23′ 8½″	3502.3008	20.8149
10″	84′ 3½″	565.5084	23′ 9⅜″	3524.2483	20.9447
11″	84′ 6⅝″	569.0270	23′ 10¼″	3546.1762	21.0750
27′	84′ 9⅞″	572.5566	23′ 11⅛″	3568.1727	21.2058
1″	85′ 1″	576.0949	24′ ⅛″	3590.2234	21.3368
2″	85′ 4¼″	579.6463	24′ 1″	3612.3557	21.4683
3″	85′ 8⅛″	583.2085	24′ 1⅞″	3634.5553	21.6003
4″	85′ 11⅜″	586.7796	24′ 2¾″	3656.8104	21.7325
5″	86′ 1½″	590.3637	24′ 3⅝″	3679.1465	21.8653
6″	86′ 4⅝″	593.9587	24′ 4½″	3701.5506	21.9984

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	86′ 7⅞″	597.5625	24′ 5⅝″	3724.0094	22.1319
8″	86′ 11″	601.1793	24′ 6¼″	3746.5493	22.2569
9″	87′ 2⅛″	604.8070	24′ 7⅛″	3769.1572	22.4002
10″	87′ 5¼″	608.4436	24′ 8⅛″	3791.8205	22.5349
11″	87′ 8⅜″	612.0931	24′ 9″	3814.5641	22.6701
28′	87′ 11½″	615.7536	24′ 9¾″	3837.3764	22.8056
1″	88′ 2⅝″	619.4228	24′ 10¾″	3860.2428	22.9415
2″	88′ 5¾″	623.1050	24′ 11½″	3883.1903	23.0779
3″	88′ 9″	626.7982	25′ ½″	3905.4063	23.2147
4″	89′ ⅛″	630.5002	25′ 1⅜″	3929.2772	23.3154
5″	89′ 3¼″	634.2152	25′ 2¼″	3952.4291	23.4894
6″	89′ 6⅜″	637.9411	25′ 3⅛″	3975.6489	23.6274
7″	89′ 9½″	641.6758	25′ 4″	3998.9235	23.7457
8″	90′ ⅝″	645.4235	25′ 4⅞″	4022.4662	23.9045
9″	90′ 3¾″	649.1821	25′ 5⅞″	4045.7028	24.0437
10″	90′ 6⅞″	652.9495	25′ 6¾″	4069.1813	24.1833
11″	90′ 11⅛″	656.7300	25′ 7⅝″	4092.3413	24.3249
29′	91′ 1¼″	660.5214	25′ 8⅜″	4116.3693	24.4637
1″	91′ 4⅜″	664.3214	25′ 9⅜″	4140.0509	24.6044
2″	91′ 7½″	668.1346	25′ 10¼″	4163.8148	24.7457
3″	91′ 10⅝″	671.9587	25′ 11⅛″	4187.6466	24.8873
4″	92′ 1¾″	675.7915	26′ 0″	4211.5326	25.0293
5″	92′ 4⅞″	679.6375	26′ ⅞″	4234.4839	25.1717
6″	92′ 8⅛″	683.4943	26′ 1¾″	4259.5364	25.2405
7″	92′ 11⅛″	687.3598	26′ 2⅝″	4283.6263	25.4577
8″	93′ 2⅜″	691.2385	26′ 3⅝″	4308.7983	25.6014
9″	93′ 5½″	695.1280	26′ 4½″	4332.0376	25.7454
10″	93′ 8⅝″	699.0263	26′ 5⅜″	4356.3319	25.8898
11″	93′ 11⅞″	702.9377	26′ 6¼″	4380.7077	26.0347
30′	94′ 2⅞″	706.8600	26′ 7″	4405.1515	26.1800
1″	94′ 6″	710.7909	26′ 8″	4429.6488	26.3255
2″	94′ 9¼″	714.7350	26′ 8⅞″	4454.2285	26.4716
3″	95′ ⅜″	718.6900	26′ 9¾″	4478.8760	26.6181
4″	95′ 3½″	722.6537	26′ 10⅝″	4503.5779	26.7649
5″	95′ 6⅝″	726.6305	26′ 11½″	4528.3612	26.9122
6″	95′ 9¾″	730.6183	27′ ⅜″	4553.2132	27.0599

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	96′ ⅞″	734.6147	27′ 1⅝″	4578.1188	27.2079
8″	96′ 4″	738.6242	27′ 2¼″	4603.1060	27.3934
9″	96′ 7¼″	742.6447	27′ 3⅛″	4628.1617	27.5153
10″	96′ 10⅜″	746.6738	27′ 4″	4653.2711	27.6545
11″	97′ 1½″	750.7161	27′ 4⅞″	4678.4627	27.8043
31′	97′ 4⅝″	754.7694	27′ 5⅝″	4703.7229	27.9544
1″	97′ 7¾″	758.8311	27′ 6⅝″	4729.0354	28.1048
2″	97′ 10⅞″	762.9062	27′ 7½″	4754.4314	28.2557
3″	98′ 2″	766.9921	27′ 8⅜″	4779.8947	28.4070
4″	98′ 5⅛″	771.0866	27′ 9¼″	4805.4116	28.5587
5″	98′ 8⅜″	775.1944	27′ 10⅛″	4831.0115	28.7109
6″	98′ 11½″	779.3131	27′ 11⅛″	4856.6792	28.8634
7″	99′ 2⅝″	783.4403	28′ 0″	4882.3999	29.0163
8″	99′ 5¾″	787.5808	28′ ⅞″	4908.2035	29.1696
9″	99′ 8⅞″	791.7322	28′ 1¾″	4934.0750	29.3234
10″	100′ 0″	795.8922	28′ 2⅝″	4960.0001	29.4774
11″	100′ 3⅛″	800.0654	28′ 3½″	4986.0075	29.6320
32′	100′ 6⅜″	804.2496	28′ 4¼″	5012.0835	29.7870
1″	100′ 9½″	808.4422	28′ 5¼″	5038.2117	29.9423
2″	101′ ⅝″	812.6481	28′ 6⅛″	5064.4229	30.0980
3″	101′ 3¾″	816.8650	28′ 7″	5090.7026	30.2543
4″	101′ 6⅞″	821.0904	28′ 8″	5117.0353	30.4107
5″	101′ 10″	825.3291	28′ 8⅞″	5143.4509	30.5677
6″	102′ 1⅛″	829.5787	28′ 9¾″	5169.9344	30.7251
7″	102′ 4⅜″	833.8368	28′ 10⅝″	5196.4709	30.8828
8″	102′ 7½″	838.1082	28′ 11½″	5223.0903	31.0410
9″	102′ 10⅝″	842.3905	29′ ⅜″	5249.7775	31.1996
10″	103′ 1¾″	846.6813	29′ 1¼″	5277.0178	31.3585
11″	103′ 4⅞″	850.9855	29′ 2⅛″	5303.3416	31.5179
33′	103′ 8″	855.3006	29′ 2⅞″	5330.2333	31.6778
1″	103′ 11⅛″	859.6240	29′ 3⅞″	5317.1767	31.8379
2″	104′ 2¼″	863.9609	29′ 4¾″	5384.2043	31.9948
3″	104′ 5⅜″	868.3087	29′ 5¾″	5411.2998	32.1595
4″	104′ 8⅝″	872.6649	29′ 6⅝″	5438.4476	32.3579
5″	104′ 11¾″	877.0346	29′ 7½″	5465.6796	32.4827
6″	105′ 2⅞″	881.4151	29′ 8⅜″	5492.9789	32.6450

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	105′ 6″	885.8040	29′ 9¼″	5520.3305	32.8075
8″	105′ 9⅛″	890.2064	29′ 10⅛″	5547.7662	32.9706
9″	106′ ¼″	894.6196	29′ 11″	5575.2693	33.1340
10″	106′ 3⅜″	899.0413	29′ 11⅞″	5602.8253	33.2978
11″	106′ 6⅝″	903.4763	30′ ¾″	5630.4643	33.4613
34′	106′ 9¾″	907.9224	30′ 1½″	5658.1723	33.6267
1″	107′ ⅞″	912.3767	30′ 2½″	5685.9315	33.7917
2″	107′ 4″	916.8445	30′ 3½″	5713.7749	33.9572
3″	107′ 7⅛″	921.3232	30′ 4⅜″	5741.6861	34.1231
4″	107′ 10¼″	925.8103	30′ 5¼″	5769.6497	34.2892
5″	108′ 1⅜″	930.3108	30′ 6⅛″	5797.6969	34.4559
6″	108′ 4⅝″	934.8223	30′ 7″	5825.8115	34.6230
7″	108′ 7¾″	939.3421	30′ 7⅞″	5853.9699	34.7904
8″	108′ 10⅞″	943.8753	30′ 8¾″	5882.2308	34.9583
9″	109′ 2″	948.4195	30′ 9⅝″	5910.5503	35.1266
10″	109′ 5⅛″	952.9720	30′ 10½″	5938.9215	35.2952
11″	109′ 8¼″	957.5380	30′ 11⅜″	5967.3768	35.4643
35′	109′ 11⅜″	962.1150	31′ ¼″	5989.9006	35.6339
1″	110′ 2⅝″	966.7001	31′ 1¼″	6024.4750	35.8037
2″	110′ 5¾″	971.2989	31′ 2⅛″	6053.1347	35.9740
3″	110′ 8⅞″	975.9085	31′ 3″	6081.8617	36.1447
4″	111′ 0″	980.5264	31′ 3⅞″	6110.6405	36.3158
5″	111′ 3⅛″	985.1579	31′ 4¾″	6139.5040	36.4873
6″	111′ 6¼″	989.8003	31′ 5⅝″	6168.4354	36.6592
7″	111′ 9⅜″	994.4509	31′ 6½″	6197.4180	36.8315
8″	112′ ½″	999.1151	31′ 7⅜″	6226.4833	37.0042
9″	112′ 3¾″	1003.7902	31′ 8¼″	6256.6205	37.1404
10″	112′ 6⅞″	1008.4736	31′ 9⅛″	6284.8074	37.3509
11″	112′ 10″	1013.1705	31′ 10⅛″	6314.0785	37.5248
36′	113′ 1⅛″	1017.8784	31′ 10⅞″	6343.4181	37.6992
1″	113′ 4¼″	1022.5944	31′ 11⅞″	6372.8083	37.8738
2″	113′ 7⅜″	1027.3240	32′ ¾″	6403.2831	38.0490
3″	113′ 10⅝″	1032.0646	32′ 1⅝″	6431.8265	38.2246
4″	114′ 1¾″	1036.8134	32′ 2½″	6461.4211	38.4005
5″	114′ 4⅞″	1041.5758	32′ 3⅜″	6491.1003	38.5761
6″	114′ 8″	1046.3491	32′ 4¼″	6520.8475	38.7537

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	114′ 11⅛″	1051.1306	32′ 5⅛″	6550.6458	38.9307
8″	115′ 2¼″	1055.9257	32′ 6″	6580.5289	39.1083
9″	115′ 5⅜″	1060.7317	32′ 6⅞″	6610.4799	39.2863
10″	115′ 9¼″	1065.5459	32′ 7⅞″	6640.4820	39.4646
11″	115′ 11⅝″	1070.3738	32′ 8¾″	6670.5695	39.6435
37′	116′ 2⅞″	1075.2126	32′ 9½″	6700.7249	39.8227
1″	116′ 6″	1080.0594	32′ 10½″	6730.9301	40.0220
2″	116′ 9⅛″	1084.9201	32′ 11⅜″	6762.2220	40.1822
3″	117′ ¼″	1089.7915	33′ ¼″	6791.5806	40.3626
4″	117′ 3½″	1094.6711	33′ 1⅛″	6821.9902	40.5434
5″	117′ 6½″	1099.5644	33′ 2″	6852.4853	40.7246
6″	117′ 9⅝″	1104.4687	33′ 2⅞″	6883.0489	40.9062
7″	118′ ¾″	1109.3810	33′ 3¾″	6913.6623	41.0882
8″	118′ 4″	1114.3071	33′ 4⅝″	6944.3618	41.2706
9″	118′ 7⅛″	1119.2440	33′ 5⅝″	6975.1286	41.4535
10″	118′ 10¼″	1124.1891	33′ 6½″	7005.9464	41.6366
11″	119′ 1⅜″	1129.1478	33′ 7⅜″	7036.8490	41.8203
38′	119′ 4½″	1134.1176	33′ 8⅛″	7067.8208	42.0043
1″	119′ 7⅝″	1139.0953	33′ 9⅛″	7098.8419	42.1887
2″	119′ 10¾″	1144.0868	33′ 10″	7129.9489	42.3736
3″	120′ 2″	1149.0892	33′ 10⅞″	7161.1238	42.5588
4″	120′ 5⅛″	1154.0997	33′ 11¾″	7192.5493	42.7444
5″	120′ 8⅜″	1159.1239	34′ ⅝″	7223.6601	42.9305
6″	120′ 11⅜″	1164.1591	34′ 1½″	7255.0395	43.1459
7″	121′ 2½″	1169.2023	34′ 2⅜″	7286.4687	43.3034
8″	121′ 5⅝″	1174.2592	34′ 3⅜″	7317.9833	43.4911
9″	121′ 8¾″	1179.3271	34′ 4¼″	7349.5664	43.6417
10″	121′ 11⅞″	1184.4030	34′ 5⅛″	7381.1994	43.8668
11″	122′ 3⅛″	1189.4927	34′ 6″	7412.9185	44.0553
39′	122′ 6¼″	1194.5934	34′ 6¾″	7444.7054	44.2442
1″	122′ 9½″	1199.7195	34′ 7¾″	7476.6519	44.4340
2″	123′ ½″	1204.8244	34′ 8⅝″	7478.4626	44.6231
3″	123′ 3⅝″	1209.9577	34′ 9½″	7540.4563	44.8123
4″	123′ 6¾″	1215.0990	34′ 10⅜″	7572.4969	45.0036
5″	123′ 9⅞″	1220.2542	34′ 11¼″	7604.6239	45.1946
6″	124′ 1⅛″	1225.4203	35′ ⅛″	7636.8193	45.3859

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	124′ 4¼″	1230.5943	35′ 1⅛″	7669.0636	45.5775
8″	124′ 7⅜″	1235.7822	35′ 2″	7701.3946	45.7697
9″	124′ 10½″	1240.9810	35′ 2⅞″	7733.7935	45.9622
10″	125′ 1⅝″	1246.1878	35′ 3¾″	7766.2423	46.1551
11″	125′ 4¾″	1251.4084	35′ 4⅝″	7798.7771	46.3484
40′	125′ 7⅞″	1256.6400	35′ 5⅜″	7831.3804	46.5422
1″	125′ 11″	1261.8794	35′ 6⅜″	7864.0324	46.7362
2″	126′ 2¼″	1267.1327	35′ 7¼″	7896.7709	46.9308
3″	126′ 5⅜″	1272.3970	35′ 8⅛″	7929.5781	47.1257
4″	126′ 8½″	1277.6692	35′ 9″	7962.4344	47.3211
5″	126′ 11⅝″	1282.9553	35′ 10″	7995.3774	47.5168
6″	127′ 2¾″	1288.2523	35′ 10⅞″	8028.2883	47.7130
7″	127′ 5⅞″	1293.5572	35′ 11¾″	8061.4484	47.9095
8″	127′ 9″	1298.8760	36′ ⅝″	8094.5952	48.1065
9″	128′ ¼″	1304.2057	36′ 1½″	8127.8099	48.3039
10″	128′ 3⅜″	1309.5433	36′ 2⅜″	8161.0738	48.5016
11″	128′ 6½″	1314.8949	36′ 3¼″	8194.4250	48.6998
41′	128′ 9⅝″	1320.2574	36′ 4½″	8227.8441	48.8984
1″	129′ ¾″	1325.6276	36′ 5″	8261.3112	49.0973
2″	129′ 3⅞″	1331.0119	36′ 5⅞″	8294.8661	49.2967
3″	129′ 7″	1336.4071	36′ 6¾″	8328.4890	49.4965
4″	129′ 10⅛″	1341.8101	36′ 7¾″	8362.1605	49.6967
5″	130′ 1⅜″	1347.2271	36′ 8⅝″	8395.9192	49.8973
6″	130′ 4½″	1352.6551	36′ 9½″	8429.7465	50.0983
7″	130′ 7⅝″	1358.0908	36′ 10⅜″	8463.6218	50.2997
8″	130′ 10¾″	1363.5406	36′ 11¼″	8497.5850	50.5015
9″	131′ 1⅞″	1369.0012	37′ ⅛″	8531.6154	50.7037
10″	131′ 5″	1374.4697	37′ 1″	8565.6951	50.9063
11″	131′ 8⅛″	1379.9521	37′ 1⅞″	8599.8614	51.1093
42′	131′ 11⅜″	1385.4456	37′ 2⅝″	8634.0969	51.3128
1″	132′ 2½″	1390.2467	37′ 3⅝″	8664.0174	51.4906
2″	132′ 5⅝″	1396.4619	37′ 4½″	8702.7505	51.7208
3″	132′ 8¾″	1401.9880	37′ 5½″	8737.1892	51.9257
4″	132′ 11⅞″	1407.5219	37′ 6⅜″	8771.6764	52.1304
5″	133′ 3″	1413.0698	37′ 7¼″	8806.2509	52.3355
6″	133′ 6⅛″	1418.6287	37′ 8⅛″	8840.8940	52.5418

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	133′ 9¼″	1424.1952	37′ 9″	8875.5844	52.7479
8″	134′ ½″	1429.7759	37′ 9⅞″	8910.3634	52.9546
9″	134′ 3⅝″	1435.3675	37′ 10¾″	8945.2102	53.1618
10″	134′ 6¾″	1440.9668	37′ 11⅝″	8980.1050	53.3691
11″	134′ 9⅞″	1446.5802	38′ ½″	9015.0878	53.5770
43′	135′ 1″	1452.2046	38′ 1¼″	9050.1390	53.7853
1″	135′ 4⅛″	1457.8365	38′ 2¼″	9085.2370	53.9939
2″	135′ 7¼″	1463.4827	38′ 3¼″	9120.3741	54.2030
3″	135′ 10½″	1469.1397	38′ 4⅛″	9155.6786	54.4126
4″	136′ 1⅝″	1474.8044	38′ 5″	9190.9810	54.6224
5″	136′ 4¾″	1480.4833	38′ 5⅞″	9226.3719	54.8323
6″	136′ 7⅞″	1486.1731	38′ 6¾″	9261.7307	55.0434
7″	136′ 11″	1491.8705	38′ 7⅝″	9297.3369	55.2544
8″	137′ 2⅛″	1497.5821	38′ 8½″	9332.9316	55.8363
9″	137′ 5¼″	1503.3046	38′ 9⅜″	9368.5942	55.6779
10″	137′ 8⅜″	1509.0348	38′ 10¼″	9404.3048	55.8902
11″	137′ 11⅝″	1514.7791	38′ 11⅛″	9440.1033	56.1029
44′	138′ 2¾″	1520.5344	38′ 11⅞″	9475.9703	56.3161
1″	138′ 5⅞″	1526.2971	39′ 1″	9511.8835	56.5295
2″	138′ 9″	1532.0742	39′ 1⅞″	9547.8864	56.7435
3″	139′ ⅛″	1537.8622	39′ 2¾″	9583.9572	56.9578
4″	139′ 3¼″	1543.6578	39′ 3⅝″	9620.0754	57.1725
5″	139′ 6⅜″	1549.4776	39′ 4½″	9656.2820	57.3877
6″	139′ 9⅝″	1555.2883	39′ 5⅜″	9692.5566	57.6033
7″	140′ ¾″	1561.1165	39′ 6¼″	9728.8780	57.8191
8″	140′ 3⅞″	1565.9591	39′ 7⅛″	9765.2891	58.0355
9″	140′ 7½″	1572.8125	39′ 8″	9801.7675	58.2523
10″	140′ 10⅛″	1578.6735	39′ 8⅞″	9838.2932	58.4323
11″	141′ 1¼″	1584.5488	39′ 9¾″	9874.9081	58.6499
45′	141′ 4⅜″	1590.4350	39′ 10½″	9911.5909	58.9050
1″	141′ 7½″	1596.3286	39′ 11⅝″	9948.3198	59.1233
2″	141′ 10¾″	1602.2366	40′ ½″	9985.1384	59.3421
3″	142′ 1⅞″	1608.1555	40′ 1⅜″	10022.025	59.5613
4″	142′ 5″	1614.0819	40′ 2¼″	10058.958	59.7808
5″	142′ 8⅛″	1620.0226	40′ 3⅛″	10095.980	60.0008
6″	142′ 11¼″	1625.9743	40′ 4″	10133.071	60.2212

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Continued.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	143′ 2⅜″	1631.9334	40′ 4⅞″	10170.208	60.4420
8″	143′ 5½″	1637.9068	40′ 5¾″	10207.435	60.6632
9″	143′ 8¾″	1643.8912	40′ 6⅝″	10244.729	60.8848
10″	143′ 11⅞″	1649.8831	40′ 7⅝″	10277.070	61.1068
11″	144′ 3″	1655.8892	40′ 8½″	10319.501	61.3292
46′	144′ 6⅛″	1661.9064	40′ 9⅜″	10357.000	61.5521
1″	144′ 9¼″	1667.9308	40′ 10¼″	10394.544	61.7752
2″	145′ ⅜″	1673.9698	40′ 11⅛″	10432.179	61.9989
3″	145′ 3½″	1680.0196	41′ 0″	10469.880	62.2229
4″	145′ 6⅝″	1686.0769	41′ ⅞″	10507.631	62.4473
5″	145′ 9⅞″	1692.1485	41′ 1¾″	10546.469	62.6722
6″	146′ 1⅛″	1698.2311	41′ 2⅝″	10583.376	62.8974
7″	146′ 4⅛″	1704.3210	41′ 3½″	10621.328	63.1230
8″	146′ 7¼″	1710.4254	41′ 4⅜″	10659.371	63.3491
9″	146′ 10⅜″	1716.5407	41′ 5⅜″	10607.481	63.5756
10″	147′ 1½″	1722.6634	41′ 6¼″	10735.638	63.8021
11″	147′ 4⅝″	1728.8005	41′ 7⅛″	10773.884	64.0296
47′	147′ 7¾″	1734.9486	41′ 7¾″	10812.199	64.2573
1″	147′ 11″	1741.1039	41′ 8⅞″	10850.559	64.4853
2″	148′ 2⅛″	1747.2738	41′ 9¾″	10889.010	64.7138
3″	148′ 5¼″	1753.4545	41′ 10⅝″	10927.528	64.9427
4″	148′ 8⅜″	1759.6426	41′ 11½″	10966.092	65.1719
5″	148′ 11½″	1765.8452	42′ ⅜″	11004.747	65.4017
6″	149′ 2⅝″	1772.0587	42′ 1¼″	11043.469	65.6318
7″	149′ 5⅞″	1778.2795	42′ 2⅛″	11082.237	65.8622
8″	149′ 8⅞″	1784.5148	42′ 3⅛″	11121.096	66.0931
9″	150′ ⅛″	1790.7610	42′ 4″	11160.022	66.3245
10″	150′ 3¼″	1797.0145	42′ 4⅞″	11197.994	66.5561
11″	150′ 6⅜″	1803.2826	42′ 5¾″	11238.057	66.7882
48′	150′ 9½″	1809.5616	42′ 6½″	11287.187	67.0208
1″	151′ ⅝″	1815.8477	42′ 7½″	11316.362	67.2536
2″	151′ 3¾″	1822.1485	42′ 8⅜″	11366.629	67.4870
3″	151′ 6⅞″	1828.4602	42′ 9¼″	11394.963	67.7209
4″	151′ 10⅛″	1834.7791	42′ 10⅛″	11434.343	67.9548
5″	152′ 1¼″	1841.1127	42′ 11″	11473.814	68.1893
6″	152′ 4⅜″	1847.4571	43′ 0″	11513.352	68.4243

CIRCUMFERENCES AND AREAS OF CIRCLES, — *Concluded.*

Diameter in feet and inches.	Circum. in feet and inches.	Area in feet.	Side of = square in ft. and in.	Imperial gallons at 1 foot in depth.	Cubic yards at 1 foot in depth.
7″	152′ 7½″	1853.8087	43′ ⅞″	11552.935	68.6560
8″	152′ 10⅝″	1860.1750	43′ 1¾″	11592.610	68.8953
9″	153′ 1¾″	1866.5521	43′ 2⅝″	11632.352	69.1315
10″	153′ 4⅞″	1872.9365	43′ 3½″	11672.140	69.3680
11″	153′ 8⅛″	1879.3355	43′ 4⅜″	11712.018	69.6050
49′	153′ 11¼″	1885.7454	43′ 5⅛″	11750.964	69.8424
1″	154′ 2⅜″	1892.1724	43′ 6⅛″	11792.018	70.0804
2″	154′ 5½″	1898.5041	43′ 7″	11831.477	70.3150
3″	154′ 8⅝″	1905.0367	43′ 7⅞″	11872.188	70.5569
4″	154′ 11⅞″	1911.4965	43′ 8¾″	11912.446	70.7961
5″	155′ 2⅞″	1917.9609	43′ 9¾″	11952.732	71.0356
6″	155′ 6″	1924.4263	43′ 10⅝″	11993.824	71.2750
7″	155′ 9¼″	1930.9188	43′ 11½″	12033.485	71.5155
8″	156′ ⅛″	1937.3159	44′ ⅜″	12073.352	71.7524
9″	156′ 3½″	1943.9140	44′ 1¼″	12114.472	71.9968
10″	156′ 6⅝″	1950.4392	44′ 2⅛″	12155.137	72.2385
11″	156′ 9¾″	1956.9691	44′ 3″	12195.831	72.4803
50′	157′ ⅞″	1963.5000	44′ 3¾″	12236.532	72.7222

TABLE OF THE CAPACITY OF CISTERNS IN GALLONS

For each 10″ of depth.

Diameter in feet.	Gallons.	Diameter in feet.	Gallons.	Diameter in feet.	Gallons.	Diameter in feet.	Gallons.
2	19.5	5	122.4	8	313.33	12	705.0
2½	30.6	5½	148.10	8½	353.72	13	827.4
3	44.06	6	176.25	9	396.56	14	959.6
3½	59.97	6½	206.85	9½	461.4	15	1101.6
4	78.33	7	239.88	10	489.2	20	1958.4
4½	99.14	7½	275.4	11	592.4	25	3059.9

TABLE OF THE PROPORTIONAL RADII OF WHEELS,

From $\frac{1}{4}''$ to $1''$ pitch.

No. of teeth.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
10	0.405	0.607	0.809	1.011	1.214	1.416	1.618
11	0.444	0.666	0.887	1.109	1.331	1.553	1.775
12	0.483	0.724	0.966	1.207	1.449	1.690	1.932
13	0.522	0.783	1.045	1.306	1.567	1.828	2.089
14	0.562	0.843	1.123	1.404	1.685	1.966	2.247
15	0.601	0.902	1.202	1.503	1.804	2.104	2.405
16	0.641	0.961	1.281	1.602	1.922	2.243	2.563
17	0.680	1.020	1.361	1.701	2.041	2.381	2.721
18	0.720	1.080	1.440	1.800	2.160	2.519	2.879
19	0.759	1.139	1.519	1.899	2.278	2.658	3.038
20	0.799	1.199	1.598	1.998	2.397	2.797	3.196
21	0.839	1.258	1.677	2.097	2.516	2.935	3.355
22	0.878	1.318	1.757	2.196	2.635	3.074	3.513
23	0.918	1.377	1.836	2.295	2.754	3.213	3.672
24	0.958	1.437	1.915	2.394	2.873	3.352	3.831
25	0.997	1.496	1.995	2.493	2.992	3.491	3.989
26	1.037	1.556	2.074	2.593	3.111	3.630	4.148
27	1.077	1.615	2.154	2.692	3.230	3.769	4.307
28	1.116	1.675	2.233	2.791	3.349	3.908	4.466
29	1.156	1.734	2.312	2.890	3.468	4.047	4.625
30	1.196	1.794	2.392	2.990	3.588	4.186	4.783
31	1.236	1.853	2.471	3.089	3.707	4.325	4.942
32	1.275	1.913	2.551	3.188	3.826	4.464	5.101
33	1.315	1.973	2.630	3.288	3.945	4.603	5.260
34	1.355	2.032	2.710	3.387	4.064	4.742	5.419
35	1.394	2.092	2.789	3.486	4.183	4.881	5.578
36	1.434	2.151	2.868	3.586	4.303	5.020	5.737
37	1.474	2.211	2.948	3.685	4.422	5.159	5.896
38	1.514	2.271	3.027	3.784	4.541	5.298	6.055
39	1.553	2.330	3.107	3.884	4.660	5.437	6.214
40	1.593	2.390	3.186	3.983	4.780	5.576	6.373
41	1.633	2.449	3.266	4.082	4.899	5.715	6.532
42	1.673	2.509	3.345	4.182	5.018	5.854	6.691
43	1.712	2.569	3.425	4.281	5.137	5.994	6.850
44	1.752	2.628	3.504	4.381	5.257	6.133	7.009

PROPORTIONAL RADII OF WHEELS, ¼″ TO 1″, — *Continued.*

No. of teeth.	¼″	⅜″	½″	⅝″	¾″	⅞″	1″
45	1.792	2.688	3.584	4.480	5.376	6.272	7.168
46	1.832	2.748	3.663	4.579	5.495	6.411	7.327
47	1.871	2.807	3.743	4.679	5.614	6.550	7.486
48	1.911	2.867	3.822	4.778	5.734	6.689	7.645
49	1.951	2.927	3.902	4.877	5.853	6.828	7.804
50	1.991	2.986	3.982	4.977	5.972	6.968	7.963
51	2.031	3.046	4.061	5.076	6.092	7.107	8.122
52	2.070	3.105	4.141	5.176	6.211	7.246	8.281
53	2.110	3.165	4.220	5.275	6.330	7.385	8.440
54	2.150	3.225	4.300	5.375	6.449	7.524	8.599
55	2.190	3.284	4.379	5.474	6.559	7.663	8.758
56	2.229	3.344	4.459	5.573	6.688	7.803	8.917
57	2.269	3.404	4.538	5.673	6.807	7.942	9.076
58	2.309	3.463	4.618	5.772	6.927	8.081	9.235
59	2.349	3.523	4.697	5.872	7.046	8.220	9.395
60	2.388	3.583	4.777	5.971	7.165	8.359	9.554
61	2.428	3.642	4.856	6.070	7.285	8.499	9.713
62	2.468	3.702	4.936	6.170	7.404	8.638	9.872
63	2.508	3.762	5.015	6.269	7.523	8.777	10.031
64	2.548	3.821	5.095	6.369	7.643	8.916	10.190
65	2.587	3.881	5.175	6.468	7.762	9.055	10.349
66	2.627	3.941	5.254	6.568	7.881	9.195	10.508
67	2.667	4.000	5.334	6.667	8.000	9.334	10.667
68	2.707	4.060	5.413	6.767	8.120	9.473	10.826
69	2.746	4.120	5.493	6.866	8.239	9.612	10.985
70	2.786	4.179	5.572	6.965	8.358	9.752	11.145
71	2.826	4.239	5.652	7.065	8.478	9.891	11.304
72	2.866	4.299	5.731	7.164	8.597	10.030	11.463
73	2.905	4.358	5.811	7.264	8.716	10.169	11.622
74	2.945	4.418	5.890	7.363	8.836	10.308	11.781
75	2.985	4.478	5.970	7.463	8.955	10.448	11.940
76	3.025	4.537	6.050	7.562	9.074	10.587	12.099
77	3.065	4.597	6.129	7.661	9.194	10.726	12.258
78	3.104	4.657	6.209	7.761	9.313	10.865	12.417
79	3.144	4.716	6.288	7.860	9.432	11.004	12.577
80	3.184	4.776	6.368	7.960	9.552	11.144	12.736
81	3.224	4.836	6.447	8.059	9.671	11.283	12.895

PROPORTIONAL RADII OF WHEELS, $\frac{1}{4}''$ TO $1''$, — *Continued.*

No. of teeth.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
82	3.263	4.895	6.527	8.159	9.790	11.422	13.054
83	3.303	4.955	6.607	8.258	9.910	11.561	13.213
84	3.343	5.015	6.686	8.358	10.029	11.701	13.372
85	3.383	5.074	6.766	8.457	10.148	11.840	13.531
86	3.423	5.134	6.845	8.556	10.268	11.979	13.690
87	3.462	5.194	6.925	8.656	10.387	12.118	13.849
88	3.502	5.253	7.004	8.755	10.506	12.258	14.009
89	3.542	5.313	7.084	8.855	10.626	12.397	14.168
90	3.582	5.373	7.163	8.954	10.745	12.536	14.327
91	3.622	5.432	7.243	9.054	10.864	12.675	14.486
92	3.661	5.492	7.323	9.153	10.984	12.815	14.645
93	3.701	5.552	7.402	9.253	11.103	12.954	14.804
94	3.741	5.611	7.482	9.352	11.223	13.093	14.963
95	3.781	5.671	7.561	9.452	11.342	13.232	15.122
96	3.820	5.731	7.641	9.551	11.461	13.371	15.282
97	3.860	5.790	7.720	9.650	11.581	13.511	15.441
98	3.900	5.850	7.800	9.750	11.700	13.650	15.600
99	3.940	5.910	7.880	9.841	11.819	13.789	15.759
100	3.980	5.969	7.959	9.949	11.938	13.928	15.918
101	4.019	6.029	8.039	10.048	12.058	14.068	16.077
102	4.059	6.089	8.118	10.148	12.177	14.207	16.236
103	4.099	6.148	8.198	10.247	12.297	14.346	16.396
104	4.139	6.208	8.277	10.347	12.416	14.485	16.555
105	4.178	6.268	8.357	10.446	12.535	14.625	16.714
106	4.218	6.327	8.436	10.546	12.655	14.764	16.873
107	4.258	6.387	8.516	10.645	12.774	14.903	17.032
108	4.298	6.447	8.596	10.744	12.893	15.042	17.191
109	4.338	6.506	8.675	10.844	13.013	15.182	17.350
110	4.377	6.566	8.755	10.943	13.132	15.321	17.509
111	4.417	6.626	8.834	11.043	13.251	15.460	17.669
112	4.457	6.685	8.914	11.142	13.371	15.599	17.828
113	4.497	6.745	8.993	11.242	13.490	15.738	17.987
114	4.536	6.805	9.073	11.341	13.609	15.878	18.146
115	4.576	6.864	9.153	11.441	13.729	16.017	18.305
116	4.616	6.924	9.232	11.540	13.848	16.156	18.464
117	4.656	6.984	9.312	11.640	13.968	16.295	18.623
118	4.696	7.043	9.391	11.739	14.087	16.435	18.782

PROPORTIONAL RADII OF WHEELS, ¼″ TO 1″, — *Continued.*

No. of teeth.	¼″	⅜″	½″	⅝″	¾″	⅞″	1″
119	4.735	7.103	9.471	11.839	14.206	16.574	18.942
120	4.775	7.163	9.550	11.938	14.326	16.713	19.101
121	4.815	7.222	9.630	12.037	14.445	16.852	19.260
122	4.855	7.282	9.710	12.137	14.564	16.992	19.419
123	4.895	7.342	9.789	12.236	14.684	17.131	19.578
124	4.934	7.402	9.869	12.336	14.803	17.270	19.737
125	4.974	7.461	9.948	12.435	14.922	17.410	19.896
126	5.014	7.521	10.028	12.535	15.042	17.549	20.056
127	5.054	7.581	10.107	12.634	15.161	17.688	20.215
128	5.093	7.640	10.187	12.734	15.280	17.827	20.374
129	5.133	7.700	10.267	12.833	15.400	17.966	20.533
130	5.173	7.760	10.346	12.933	15.519	18.106	20.692
131	5.213	7.819	10.426	13.032	15.638	18.245	20.851
132	5.253	7.879	10.505	13.132	15.758	18.384	21.010
133	5.292	7.939	10.585	13.231	15.877	18.523	21.170
134	5.332	7.998	10.664	13.331	15.997	18.663	21.329
135	5.372	8.058	10.744	13.430	16.116	18.802	21.488
136	5.412	8.118	10.824	13.529	16.235	18.941	21.647
137	5.452	8.177	10.903	13.629	16.355	19.080	21.806
138	5.491	8.237	10.983	13.728	16.474	19.220	21.965
139	5.531	8.297	11.062	13.828	16.593	19.359	22.124
140	5.571	8.356	11.142	13.927	16.713	19.498	22.284
141	5.611	8.416	11.221	14.027	16.832	19.637	22.443
142	5.650	8.476	11.301	14.126	16.951	19.777	22.602
143	5.690	8.535	11.381	14.226	17.071	19.916	22.761
144	5.730	8.595	11.460	14.325	17.190	20.055	22.920
145	5.770	8.655	11.540	14.425	17.309	20.194	23.079
146	5.810	8.714	11.619	14.524	17.429	20.334	23.238
147	5.849	8.774	11.699	14.623	17.548	20.473	23.398
148	5.889	8.834	11.778	14.723	17.668	20.612	23.557
149	5.929	8.893	11.858	14.822	17.787	20.751	23.716
150	5.969	8.953	11.938	14.922	17.906	20.891	23.875
151	6.009	9.013	12.017	15.021	18.026	21.030	24.034
152	6.048	9.072	12.097	15.121	18.145	21.169	24.193
153	6.088	9.132	12.176	15.220	18.264	21.308	24.352
154	6.128	9.192	12.256	15.320	18.384	21.448	24.512
155	6.168	9.252	12.335	15.419	18.503	21.587	24.671

PROPORTIONAL RADII OF WHEELS, $\frac{1}{4}''$ TO $1''$, — *Continued.*

No. of teeth.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
156	6.207	9.311	12.415	15.519	18.622	21.726	24.830
157	6.247	9.371	12.494	15.618	18.742	21.865	24.989
158	6.287	9.431	12.574	15.718	18.861	22.005	25.148
159	6.327	9.490	12.654	15.817	18.980	22.144	25.307
160	6.367	9.550	12.733	15.917	19.100	22.283	25.466
161	6.406	9.610	12.813	16.016	19.219	22.422	25.626
162	6.446	9.669	12.892	16.115	19.339	22.562	25.785
163	6.486	9.729	12.972	16.215	19.458	22.701	25.944
164	6.526	9.789	13.052	16.314	19.577	22.840	26.103
165	6.566	9.848	13.131	16.414	19.697	22.979	26.262
166	6.605	9.908	13.211	16.513	19.816	23.119	26.421
167	6.645	9.968	13.290	16.613	19.935	23.258	26.580
168	6.685	10.027	13.370	16.712	20.055	23.397	26.740
169	6.725	10.087	13.449	16.812	20.174	23.536	26.899
170	6.764	10.147	13.529	16.911	20.293	23.676	27.058
171	6.804	10.206	13.609	17.011	20.413	23.815	27.217
172	6.844	10.266	13.688	17.110	20.532	23.954	27.376
173	6.884	10.326	13.768	17.210	20.651	24.093	27.535
174	6.924	10.385	13.847	17.309	20.771	24.233	27.694
175	6.963	10.445	13.927	17.409	20.890	24.372	27.854
176	7.003	10.505	14.006	17.508	21.010	24.511	28.017
177	7.043	10.564	14.086	17.607	21.129	24.650	28.172
178	7.083	10.624	14.166	17.707	21.248	24.790	28.331
179	7.123	10.684	14.245	17.806	21.368	24.929	28.490
180	7.162	10.744	14.325	17.906	21.487	25.068	28.649
181	7.202	10.803	14.404	18.005	21.606	25.207	28.808
182	7.242	10.863	14.484	18.105	21.726	25.347	28.968
183	7.282	10.923	14.563	18.204	21.845	25.486	29.127
184	7.321	10.982	14.643	18.304	21.964	25.625	29.286
185	7.361	11.042	14.723	18.403	22.084	25.764	29.445
186	7.401	11.102	14.802	18.503	22.203	25.904	29.607
187	7.441	11.161	14.882	18.602	22.323	26.043	29.763
188	7.481	11.221	14.961	18.702	22 442	26.182	29.923
189	7.520	11.281	15.041	18.801	22.561	26.321	30.082
190	7.560	11.340	15.120	18.901	22.681	26.461	30.241
191	7.600	11.400	15.200	19.000	22.800	26.600	30.400
192	7.640	11.460	15.280	19.099	22.919	26.739	30.559

PROPORTIONAL RADII OF WHEELS, $\frac{1}{4}''$ TO $1''$, — *Continued.*

No. of teeth.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
193	7.689	11.519	15.359	19.199	23.039	26.878	30.718
194	7.719	11.579	15.439	19.298	23.158	27.018	30.877
195	7.759	11.639	15.518	19.398	23.277	27.157	31.037
196	7.799	11.698	15.598	19.497	23.397	27.296	31.196
197	7.839	11.758	15.677	19.597	23.516	27.436	31.355
198	7.879	11.818	15.757	19.696	23.636	27.575	31.514
199	7.918	11.877	15.837	19.796	23.755	27.714	31.673
200	7.958	11.937	15.916	19.895	23.874	27.853	31.832
201	7.998	11.997	15.996	19.995	23.994	27.993	31.991
202	8.038	12.056	16.075	20.094	24.113	28.132	32.151
203	8.077	12.116	16.155	20.194	24.232	28.271	32.310
204	8.117	12.176	16.234	20.293	24.352	28.410	32.469
205	8.157	12.236	16.314	20.393	24.471	28.550	32.628
206	8.197	12.295	16.394	20.492	24.590	28.689	32.787
207	8.237	12.355	16.473	20.591	24 710	28.828	32.946
208	8.276	12.415	16.553	20.691	24.829	28.967	33.106
209	8.316	12.474	16.632	20.790	24.948	29.107	33.265
210	8.356	12.534	16.712	20.890	25.068	29.246	33.424
211	8.396	12.594	16.791	20.989	25.187	29.385	33.583
212	8.436	12.653	16.871	21.089	25.307	29.524	33.742
213	8.475	12.713	16.951	21.188	25.426	29.664	33.901
214	8.515	12.773	17.030	21.288	25.545	29.803	34.060
215	8.555	12.832	17.110	21.387	25.665	29.942	34.220
216	8.595	12.892	17.189	21.487	25.784	30.081	34.379
217	8.634	12.952	17.269	21.586	25.903	30.221	34.538
218	8.674	13.011	17.349	21.686	26.023	30.360	34.697
219	8.714	13.071	17.420	21.786	26.142	30.499	34.856
220	8.754	13.131	17.508	21.885	26.261	30.638	35.015
221	8.794	13.190	17.587	21.984	26.381	30.778	35.174
222	8.833	13.250	17.667	22.084	26.500	30.917	35.334
223	8.873	13.310	17.746	22.183	26.620	31.056	35.493
224	8.913	13.369	17.826	22.282	26.739	31.195	5.652
225	8.953	13.429	17.906	22.382	26.858	31.335	35.811
226	8.993	13.489	17.985	22.481	26.978	31.474	35.970
227	9.032	13.548	18.065	22.581	27.097	31.613	36.129
228	9.072	13.608	18.144	22.680	27.216	31.752	36.289
229	9.112	13.668	18.224	22.780	27.336	31.892	36.448

PROPORTIONAL RADII OF WHEELS, ¼″ TO 1″, — *Continued.*

No. of teeth.	¼″	⅜″	½″	⅝″	¾″	⅞″	1″
230	9.152	13.728	18.303	22.879	27.455	32.031	36.607
231	9.191	13.787	18.383	22.979	27.574	32.170	36.766
232	9.231	13.847	18.463	23.078	27.694	32.309	36.925
233	9.271	13.907	18.542	23.178	27.813	32.449	37.084
234	9.311	13.966	18.622	23.277	27.933	32.588	37.243
235	9.351	14.026	18.701	23.377	28.052	32.727	37.403
236	9.390	14.086	18.781	23.476	28.171	32.867	37.562
237	9.430	14.145	18.860	23.576	28.291	33.006	37.721
238	9.470	14.205	18.940	23.675	28.410	33.145	37.880
239	9.510	14.265	19.020	23.774	28.529	33.284	38.039
240	9.550	14.324	19.099	23.874	28.649	33.424	38.198
241	9.589	14.384	19.179	23.973	28.768	33.563	38.357
242	9.629	14.444	19.258	24.073	28.887	33.702	38.517
243	9.669	14.503	19.338	24.172	29.007	33.841	38.676
244	9.709	14.563	19.417	24.272	29.126	33.981	38.835
245	9.749	14.623	19.497	24.371	29.246	34.120	38.994
246	9.788	14.682	19.577	24.471	29.365	34.259	39.153
247	9.828	14.742	19.656	24.570	29.484	34.398	39.312
248	9.868	14.802	19.736	24.670	29.604	34.538	39.472
249	9.908	14.861	19.815	24.769	29.723	34.677	39.631
250	9.947	14.921	19.895	24.869	29.842	34.816	39.790
251	9.987	14.981	19.974	24.968	29.962	34.955	39.949
252	10.027	15.041	20.054	25.068	30.081	35.095	40.108
253	10.067	15.100	20.134	25.167	30.200	35.234	40.267
254	10.107	15.160	20.213	25.267	30.320	35.373	40.426
255	10.146	15.220	20.293	25.366	30.439	35.512	40.586
256	10.186	15.279	20.372	25.465	30.559	35.652	40.745
257	10.226	15.339	20.452	25.565	30.678	35.791	40.904
258	10.266	15.399	20.532	25.664	30.797	35.930	41.063
259	10.306	15.458	20.611	25.764	30.917	36.069	41.222
260	10.345	15.518	20.691	25.863	31.036	36.209	41.381
261	10.385	15 578	20.770	25.963	31.155	36.348	41.540
262	10.425	15.637	20.850	26.062	31.275	36.487	41.700
263	10.465	15.697	20.929	26.162	31.394	36.626	41.859
264	10.504	15.757	21.009	26.261	31.513	36.766	42.018
265	10.544	15.816	21.089	26.361	31.633	36.905	42.177
266	10.584	15.876	21.168	26.460	31.752	37.044	42.336

PROPORTIONAL RADII OF WHEELS, $\frac{1}{4}''$ TO $1''$, — *Concluded.*

No. of teeth.	$\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
267	10.624	15.936	21.248	26.560	31.872	37.183	42.495
268	10.664	15.995	21.327	26.659	31.991	37.323	42.655
269	10.703	16.055	21.407	26.759	32.110	37.462	42.814
270	10.743	16.115	21.486	26.858	32.230	37.601	42.973
271	10.783	16.175	21.566	26.958	32.349	37.741	43.132
272	10.823	16.234	21.646	27.057	32.468	37.880	43.291
273	10.863	16.294	21.725	27.156	32.588	38.019	43.450
274	10.902	16.354	21.805	27.256	32.707	38.158	43.609
275	10.942	16.413	21.884	27.355	32.826	38.298	43.769
276	10.982	16.473	21.964	27.455	32.946	38.437	43.928
277	11.022	16.433	22.043	27.554	33.065	38.576	44.087
278	11.062	16.592	22.123	27.654	33.185	38.715	44.246
279	11.101	16.652	22.203	27.753	33.304	38.855	44.405
280	11.141	16.712	22.282	27.853	33.423	38.994	44.564
281	11.181	16.771	22.362	27.952	33.543	39.133	44.724
282	11 221	16.831	22.441	28.052	33.662	39.272	44.883
283	11.260	16.891	22.521	28.151	33.781	39.412	45.042
284	11.300	16.950	22.600	28.251	33.901	39.551	45.201
285	11.340	17.010	22.680	28.350	34.020	39.690	45.360
286	11.380	17.070	22.760	28.450	34.139	39.829	45.519
287	11.420	17.129	22.839	28.549	34.259	39.969	45.678
288	11.459	17.189	22.919	28.648	34.378	40.108	45.838
289	11.499	17.249	22.998	28.748	34.498	40.247	45.997
290	11.539	17.308	23.078	28.847	34.617	40.386	46.156
291	11.579	17.368	23.158	28.947	34.736	40.526	46.315
292	11.619	17.428	23.237	29.046	34.856	40.665	36.474
293	11.658	17.488	23.317	29.146	34.975	40.804	46.633
294	11.698	17.547	23.396	29.245	35.094	40.943	46.792
295	11.738	17.607	23.476	29.345	35.214	41.083	46.952
296	11.778	17.667	23.555	29.444	35.333	41.222	47.111
297	11.817	17.726	23.635	29.544	35.452	41.361	47.270
298	11.857	17.786	23.715	29.643	35.572	41.500	47.429
299	11.897	17.846	23.794	29.743	35.691	41.640	47.588
300	11.937	17.905	23.874	29.842	35.811	41.779	47.747

TABLE OF THE PROPORTIONAL RADII OF WHEELS,

From $1\frac{1}{4}''$ to $3''$ pitch.

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
15	3.006	3.607	4.209	4.810	5.411	6.012	7.215
16	3.204	3.844	4.485	5.126	5.767	6.407	7.689
17	3.401	4.082	4.762	5.442	6.122	6.803	8.163
18	3.599	4.319	5.039	5.759	6.479	7.198	8.638
19	3.797	4.557	5.316	6.076	6.835	7.594	9.113
20	3.995	4.794	5.593	6.392	7.192	7.991	9.589
21	4.193	5.032	5.871	6.710	7.548	8.387	10.064
22	4.392	5.270	6.148	7.027	7.905	8.783	10.540
23	4.590	5.508	6.426	7.344	8.262	9.180	11.016
24	4.788	5.746	6.704	7.661	8.619	9.577	11.492
25	4.987	5.984	6.981	7.979	8.976	9.973	11.968
26	5.185	6.222	7.259	8.296	9.333	10.370	12.444
27	5.384	6.460	7.537	8.614	9.691	10.767	12.921
28	5.582	6.699	7.815	8.931	10.048	11.164	13.397
29	5.781	6.937	8.093	9.249	10.405	11.561	13.874
30	5.979	7.175	8.371	9.567	10.763	11.958	14.350
31	6.178	7.413	8.649	9.885	11.120	12.356	14.827
32	6.376	7.652	8.927	10.202	11.478	12.753	15.303
33	6.575	7.890	9.205	10.520	11.835	13.150	15.780
34	6.774	8.128	9.483	10.838	12.193	13.547	16.257
35	6.972	8.367	9.761	11.156	12.550	13.945	16.734
36	7.171	8.605	10.040	11.474	12.908	14.342	17.211
37	7.370	8.844	10.318	11.972	13.266	14.740	17.688
38	7.569	9.082	10.596	12.110	13.623	15.137	18.164
39	7.767	9.321	10.874	12.428	13.981	15.534	18.641
40	7.966	9 559	11.152	12.746	14.339	15.932	19.118
41	8.165	9.798	11.431	13.064	14.696	16.329	19.595
42	8.363	10.036	11.709	13.382	15.054	16.727	20.072
43	8.562	10.275	11.987	13.700	15.412	17.124	20.549
44	8.761	10.513	12.265	14.018	15.770	17.522	21.026
45	8.960	10.752	12.544	14.336	16.128	17.920	21.503
46	9.159	10.990	12.822	14.654	16.485	18.317	21.981
47	9.357	11.229	13.100	14.972	16.843	18.715	22.458
48	9.556	11.467	13.379	15.290	17.201	19.112	22.935
49	9.755	11.706	13.657	15.608	17.559	19.510	23.412

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$, — *Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
50	9.954	11.945	13.935	15.926	17.917	19.908	23.889
51	10.153	12.183	14.214	16.244	18.275	20.305	24.366
52	10.351	12.422	14.492	16.562	18.633	20.703	24.843
53	10.550	12.660	14.770	16.880	18.990	21.100	25.320
54	10.749	12.899	15.049	17.198	19.348	21.498	25.798
55	10.948	13.137	15.327	17.517	19.706	21.896	26.275
56	11.147	13.376	15.605	17.835	20.064	22.293	26.752
57	11.346	13.615	15.884	18.153	20.422	22.691	27.229
58	11.544	13.853	16.162	18.471	20.780	23.089	27.706
59	11.743	14.092	16.441	18.789	21.138	23.486	28.184
60	11.942	14.330	16.719	19.107	21.496	23.884	28.661
61	12.141	14.569	16.997	19.425	21.854	24.282	29.138
62	12.340	14.808	17.276	19.744	22.212	24.680	29.615
63	12.539	15.046	17.554	20.062	22.570	25.077	30.093
64	12.738	15.285	17.833	20.380	22.928	25.475	30.570
65	12.936	15.524	18.111	20.698	23.285	25.873	31.047
66	13.135	15.762	18.389	21.016	23.643	26.270	31.525
67	13.334	16.001	18.668	21.335	24.001	26.668	32.002
68	13.533	16.240	18.946	21.653	24.359	27.066	32.479
69	13.732	16.478	19.225	21.971	24.717	27.464	32.956
70	13.931	16.717	19.503	22.289	25.075	27.861	33.434
71	14.130	16.956	19.781	22.607	25.433	28.259	33.911
72	14.328	17.194	20.060	22.926	25.791	28.657	34.388
73	14.527	17.433	20.338	23.244	26.149	29.055	34.866
74	14.726	17.671	20.617	23.562	26.507	29.452	35.343
75	14.925	17.910	20.895	23.880	26.865	29.850	35.820
76	15.124	18.149	21.174	24.198	27.223	30.248	36.298
77	15.323	18.387	21.452	24.517	27.581	30.646	36.775
78	15.522	18.626	21.731	24.835	27.939	31.044	37.252
79	15.721	18.865	22.009	25.153	28.297	31.441	37.730
80	15.920	19.103	22.287	25.471	28.655	31.839	38.207
81	16.118	19.342	22.566	25.790	29.013	32.237	38.684
82	16.317	19.581	22.844	26.108	29.371	32.635	39.162
83	16.516	19.820	23.123	26.426	29.729	33.033	39.639
84	16.715	20.058	23.401	26.744	30.087	33.430	40.116
85	16.914	20.297	23.680	27.063	30.445	33.828	40.594
86	17.113	20.536	23.958	27.381	30.803	34.226	41.071

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$, — *Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
87	17.312	20.774	24.237	27.699	31.161	34.624	41.548
88	17.511	21.013	24.515	28.017	31.519	35.022	42.026
89	17.710	21.252	24.794	28.335	31.877	35.415	42.503
90	17.909	21.490	25.072	28.654	32.235	35.817	42.981
91	18.107	21.729	25.350	28.972	32.593	36.215	43.458
92	18.306	21.968	25.629	29.290	32.952	36.613	43.935
93	18.505	22.206	25.907	29.608	33.309	37.011	44.413
94	18.704	22.445	26.186	29.927	33.668	37.408	44.890
95	18.903	22.684	26.464	30.245	34.026	37.806	45.367
96	19.102	22.922	26.743	30.563	34.384	38.204	45.845
97	19.301	23.161	27.021	30.881	34.742	38.602	46.322
98	19.500	23.400	27.300	31.200	35.100	39.000	46.800
99	19.699	23.638	27.578	31.518	35.458	39.397	47.277
100	19.898	23.877	27.857	31.836	35.816	39.795	47.754
101	20.097	24.116	28.135	32.155	36.174	40.193	48.232
102	20.295	24.355	28.414	32.473	36.532	40.591	48.709
103	20.494	24.593	28.692	32.791	36.890	40.989	49.187
104	20.693	24.832	28.971	33.109	37.248	41.387	49.664
105	20.892	25.071	29.249	33.428	37.606	41.784	50.141
106	21.091	25.309	29.528	33.746	37.964	42.182	50.619
107	21.290	25.548	29.806	34.064	38.322	42.580	51.096
108	21.489	25.787	30.084	34.382	38.680	42.978	51.573
109	21.688	26.025	30.363	34.701	39.038	43.376	52.051
110	21.887	26.264	30.641	35.019	39.396	43.774	52.528
111	22.086	26.503	30.920	35.337	39.754	44.171	53.006
112	22.285	26.742	31.198	35.655	40.112	44.569	53.483
113	22.484	26.980	31.477	35.974	40.470	44.967	53.960
114	22.682	27.219	31.755	36.292	40.828	45.365	54.438
115	22.881	27.458	32.034	36.610	41.186	45.763	54.915
116	23.080	27.696	32.312	36.928	41.544	46.161	55.393
117	23.279	27.935	32.591	37.247	41.903	46.558	55.870
118	23.478	28.174	32.869	37.565	42.261	46.956	56.347
119	23.677	28.412	33.148	37.883	42.619	47.354	56.825
120	23.876	28.651	33.426	38.202	42.977	47.752	57.302
121	24.075	28.890	33.705	38.520	43.335	48.150	57.780
122	24.274	29.129	33.983	38.838	43.693	48.548	58.257
123	24.473	29.367	34.262	39.156	44.051	48.945	58.735

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$,—*Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
124	24.672	29.606	34.540	39.475	44.409	49.343	59.212
125	24.871	29.845	34.819	39.793	44.767	49.741	59.690
126	25.070	30.083	35.097	40.111	45.125	50.139	60.167
127	25.268	30.322	35.376	40.429	45.483	50.537	60.644
128	25.467	30.561	35.654	40.748	45.841	50.935	61.122
129	25.666	30.800	35.933	41.066	46.199	51.333	61.599
130	25.865	31.038	36.211	41.384	46.557	51.730	62.077
131	26.064	31.277	36.490	41.703	46.915	52.128	62.554
132	26.263	31.516	36.768	42.021	47.274	52.526	63.031
133	26.462	31.754	37.047	42.339	47.632	52.924	63.500
134	26.661	31.993	37.325	42.657	47.990	53.322	63.986
135	26.860	32.232	37.604	42.976	48.348	53.720	64.464
136	27.059	32.471	37.882	43.294	48.706	54.118	64.941
137	27.258	32.709	38.161	43.612	49.064	54.515	65.418
138	27.457	32.948	38.439	43.931	49.422	54.913	65.896
139	27.656	33.187	38.718	44.249	49.780	55.311	66.373
140	27.855	33.426	38.996	44.567	50.138	55.709	66.851
141	28.053	33.664	39.275	44.885	50.496	56.107	67.328
142	28.252	33.903	39.553	45.204	50.854	56.505	67.806
143	28.451	34.141	39.832	45.522	51.212	56.902	68.283
144	28.650	34.380	40.110	45.840	51.570	57.300	68.760
145	28.849	34.619	40.389	46.159	51.928	57.698	69.238
146	29.048	34.858	40.667	46.477	52.286	58.096	69.715
147	29.247	35.096	40.946	46.795	52.645	58.494	70.193
148	29.446	35.335	41.224	47.113	53.003	58.892	70.670
149	29.645	35.574	41.503	47.432	53.361	59.290	71.148
150	29.844	35.813	41.781	47.750	53.719	59.687	71.625
151	30.043	36.051	42.060	48.068	54.077	60.085	72.102
152	30.242	36.290	42.338	48.387	54.435	60.483	72.580
153	30.441	36.529	42.617	48.705	54.793	60.881	73.057
154	30.639	36.767	42.895	49.023	55.151	61.271	73.535
155	30.838	37.006	43.174	49.341	55.509	61.677	74.012
156	31.037	37.245	43.452	49.660	55.867	62.075	74.490
157	31.236	37.483	43.731	49.978	56.225	62.472	74.967
158	31.435	37.722	44.009	50.296	56.583	62.870	75.444
159	31.634	37.961	44.288	50.615	56.941	63.268	75.922
160	31.833	38 200	44.566	50.933	57.299	63.666	76.399

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$,—*Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
161	32.032	38.438	44.845	51.251	57.658	64.064	76.877
162	32.231	38.677	45.123	51.569	58.016	64.462	77.354
163	32.430	38.917	45.402	51.888	58.374	64.860	77.832
164	32.629	39.155	45.680	52.206	58.732	65.258	78.309
165	32.828	39.393	45.959	52.524	59.090	65.655	78.786
166	33.027	39.632	46.237	52.843	59.448	66.053	79.264
167	33.226	39.871	46.516	53.161	59.806	66.451	79.741
168	33.425	40.109	46.794	53.479	60.164	66.849	80.219
169	33.623	40.348	47.073	53.797	60.522	67.247	80.696
170	33.822	40.587	47.351	54.116	60.880	67.645	81.174
171	34.021	40.826	47.630	54.434	61.238	68.043	81.651
172	34.220	41.064	47.908	54.752	61.596	68.440	82.129
173	34.419	41.303	48.187	55.071	61.954	68.838	82.606
174	34.618	41.542	48.465	55.389	62.313	69.236	83.083
175	34.817	41.780	48.744	55.707	62.671	69.634	83.561
176	35.016	42.019	49.022	56.026	63.029	70.032	84.038
177	35.215	42.258	49.301	56.344	63.387	70.430	84.516
178	35.414	42.497	49.579	56.662	63.745	70.828	84.993
179	35.613	42.735	49.858	56.980	64.103	71.226	85.471
180	35.812	42.974	50.136	57.299	64.461	71.623	85.948
181	36.011	43.213	50.415	57.617	64.819	72.021	86.425
182	36.210	43.451	50.693	57.935	65.177	72.419	86.903
183	36.408	43.600	50.972	58.254	65.535	72.817	87.380
184	36.607	43.929	51.250	58.572	65.893	73.215	87.858
185	36.806	44.168	51.529	58.890	66.251	73.613	88.335
186	37.005	44.406	51.807	59.208	66.610	74.011	88.813
187	37.204	44.645	52.086	59.527	66.968	74.408	89.290
188	37.403	44.884	52.364	59.845	67.326	74.806	89.768
189	37.602	45.123	52.643	60.163	67.684	75.204	90.245
190	37.801	45.361	52.921	60.482	68.042	75.602	90.722
191	38.000	45.600	53.200	60.800	68.400	76.000	91.200
192	38.199	45.839	53.478	61.118	68.758	76.398	91.077
193	38.398	46.077	53.757	61.437	69.116	76.796	92.155
194	38.597	46.316	54.035	61.755	69.474	77.194	92.632
195	38.796	46.555	54.314	62.073	69.832	77.591	93.110
196	38.995	46.794	54.593	62.391	70.190	77.999	93.587
197	39.194	47.032	54.871	62.710	70.548	78.387	94.065

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$,—*Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
198	39.393	47.271	55.150	63.028	70.907	78.785	94.542
199	39.591	47.510	55.428	63.346	71.265	79.183	95.019
200	39.790	47.748	55.707	63.665	71.623	79.581	95.497
201	39.989	47.987	55.985	63.983	71.981	79.979	95.974
202	40.188	48.226	56.264	64.301	72.339	80.377	96.452
203	40.387	48.465	56.542	64.619	72.697	80.774	96.929
204	40.586	48.703	56.821	64.938	73.055	81.172	97.407
205	40.785	48.942	57.099	65.256	73.410	81.570	97.884
206	40.984	49.181	57.378	65.574	73.771	81.968	98.362
207	41.183	49.420	57.656	65.893	74.129	82.366	98.839
208	41.382	49.658	57.935	66.211	74.487	82.764	99.317
209	41.581	49.897	58.213	66.529	74.845	83.162	99.794
210	41.780	50.136	58.492	66.848	75.204	83.560	100.271
211	41.979	50.374	58.770	67.166	75.562	83.957	100.749
212	42.178	50.613	59.049	67.484	75.920	84.355	101.226
213	42.377	50.852	59.327	67.803	76.278	84.753	101.704
214	42.576	51.091	59.606	68.121	76.636	85.151	102.181
215	42.774	51.329	59.884	68.439	76.994	85.549	102.659
216	42.973	51.568	60.163	68.757	77.352	85.947	103.136
217	43.172	51.807	60.441	69.076	77.710	86.345	103.614
218	43.371	52.046	60.720	69.394	78.068	86.743	104.091
219	43.570	52.284	60.998	69.712	78.426	87.140	104.568
220	43.769	52.523	61.277	70.031	78.784	87.538	105.046
221	43.968	52.762	61.555	70.349	79.143	87.936	105.523
222	44.162	53.000	61.834	70.667	79.501	88.334	106.001
223	44.366	53.239	62.112	70.986	79.859	88.732	106.478
224	44.565	53.478	62.391	71.304	80.217	89.130	106.956
225	44.764	53.717	62.669	71.622	80.575	89.528	107.433
226	44.963	53.955	62.948	71.940	80.933	89.926	107.911
227	45.162	54.194	63.226	72.259	81.291	90.323	108.388
228	45.361	54.433	63.505	72.577	81.649	90.721	108.866
229	45.560	54.672	63.783	72.895	82.007	91.119	109.343
230	45.759	54.910	64.062	73.214	82.365	91.517	109.820
231	45.957	55.149	64.340	73.532	82.723	91.915	110.298
232	46.156	55.388	64.619	73.850	83.082	92.313	110.775
233	46.355	55.626	64.897	74.169	83.440	92.711	111.253
234	46.554	55.865	65.176	74.487	83.798	93.109	111.730

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$, — *Continued.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
235	46.753	56.104	65.454	74.805	84.156	93.506	112.208
236	46.952	56.343	65.733	75.123	84.514	93.904	112.685
237	47.151	56.581	66.012	75.442	84.872	94.302	113.163
238	47.350	56.820	66.290	75.760	85.230	94.700	113.640
239	47.549	57.059	66.569	76.078	85.588	95.098	114.117
240	47.748	57.297	66.847	76.397	85.946	95.496	114.595
241	47.947	57.536	67.126	76.715	86.304	95.894	115.072
242	48.146	57.775	67.404	77.033	86.662	96.292	115.550
243	48.345	58.014	67.683	77.352	87.020	96.689	116.027
244	48.544	58.252	67.961	77.670	87.379	97.087	116.505
245	48.743	58.491	68.240	77.988	87.737	97.485	116.982
246	48.942	58.730	68.518	78.306	88.095	97.883	117.460
247	49.140	58.969	68.797	78.625	88.453	98.281	117.937
248	49.339	59.207	69.075	78.943	88.811	98.679	118.415
249	49.538	59.446	69.354	79.261	89.169	99.077	118.892
250	49.737	59.685	69.632	79.580	89.527	99.475	119.369
251	49.936	59.923	69.911	79.898	89.885	99.872	119.847
252	50.135	60.162	70.189	80.216	90.243	100.270	120.324
253	50.334	60.401	70.468	80.535	90.601	100.668	120.802
254	50.533	60.640	70.746	80.853	90.959	101.066	121.279
255	50.732	60.878	71.025	81.171	91.318	101.464	121.757
256	50.931	61.117	71.303	81.489	91.676	101.862	122.234
257	51.130	61.356	71.582	81.808	92.034	102.260	122.712
258	51.329	61.595	71.860	82.126	92.392	102.658	123.189
259	51.528	61.833	72.139	82.444	92.750	103.055	123.667
260	51.727	62.072	72.417	82.763	93.108	103.453	124.144
261	51.926	62.311	72.696	83.081	93.466	103.851	124.621
262	52.125	62.549	72.974	83.399	93.824	104.249	125.099
263	52.323	62.788	73.253	83.718	94.182	104.647	125.576
264	52.522	63.027	73.531	84.036	94.540	105.045	126.054
265	52.721	63.266	73.810	84.354	94.898	105.443	126.531
266	52.920	63.504	74.088	84.673	95.257	105.841	127.009
267	53.119	63.743	74.367	84.991	95.615	106.239	127.486
268	53.318	63.982	74.645	85.309	95.973	106.636	127.964
269	53.517	64.221	74.924	85.627	96.331	107.034	128.441
270	53.716	64.459	75.202	85.946	96.689	107.432	128.919
271	53.915	64.698	75.481	86.264	97.047	107.830	129.396

PROPORTIONAL RADII OF WHEELS, $1\frac{1}{4}''$ TO $3''$,—*Concluded.*

No. of teeth.	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	$2''$	$2\frac{1}{4}''$	$2\frac{1}{2}''$	$3''$
272	54.114	64.937	75.760	86.582	97.405	108.228	129.873
273	54.313	65.175	76.038	86.901	97.763	108.626	130.351
274	54.512	65.414	76.317	87.219	98.121	109.024	130.828
275	54.711	65.653	76.595	87.537	98.479	109.422	131.306
276	54.910	65.892	76.874	87.856	98.837	109.819	131.783
277	55.109	66.130	77.152	88.174	99.196	110.217	132.261
278	55.308	66.369	77.431	88.492	99.554	110.615	132.738
279	55.507	66.608	77.709	88.810	99.912	111.013	133.216
280	55.705	66.847	77.988	89.129	100.270	111.411	133.693
281	55.904	67.085	78.266	89.447	100.628	111.809	134.171
282	56.103	67.324	78.545	89.765	100.986	112.207	134.648
283	56.302	67.563	78.823	90.084	101.344	112.605	135.125
284	56.501	67.801	79.102	90.402	101.702	113.002	135.603
285	56.700	68.040	79.380	90.720	102.060	113.400	136.080
286	56.899	68.279	79.659	91.039	102.418	113.798	136.558
287	57.098	68.518	79.937	91.357	102.776	114.196	137.035
288	57.297	68.756	80.216	91.675	103.135	114.594	137.513
289	57.496	68.995	80.494	91.993	103.493	114.992	137.990
290	57.695	69.234	80.773	92.312	103.851	115.390	138.468
291	57.894	69.473	81.051	92.630	104.209	115.788	138.945
292	58.093	69.711	81.330	92.948	104.567	116.185	139.423
293	58.292	69.950	81.608	93.267	104.925	116.583	139.900
294	58.491	70.189	81.887	93.585	105.283	116.981	140.377
295	58.690	70.427	82.165	93.903	105.641	117.379	140.855
296	58.888	70.666	82.444	94.222	105.999	117.777	141.333
297	59.087	70.905	82.722	94.540	106.357	118.175	141.810
298	59.286	71.144	83.001	94.858	106.715	118.573	142.287
299	59.485	71.382	83.279	95.177	107.074	118.971	142.765
300	59.684	71.621	83.558	95.495	107.432	119.369	143.242

A TABLE OF NUMBERS FOR OBTAINING THE RADIUS OF ANY WHEEL, HAVING ANY NUMBER OF TEETH,

From $\frac{1}{8}''$ to $6''$ pitch, advancing by eighths.

Pitch.	Multiplier.	Pitch.	Multiplier.
$\frac{1}{8}''$	.0199	$3\frac{1}{8}''$	.4973
$\frac{1}{4}''$	.0398	$3\frac{1}{4}''$	.5172
$\frac{3}{8}''$	.0597	$3\frac{3}{8}''$	.5371
$\frac{1}{2}''$	.0796	$3\frac{1}{2}''$	.557
$\frac{5}{8}''$	.0995	$3\frac{5}{8}''$	.577
$\frac{3}{4}''$	.1194	$3\frac{3}{4}''$	.5968
$\frac{7}{8}''$	.1393	$3\frac{7}{8}''$	.6167
$1''$	.1591	$4''$	.6366
$1\frac{1}{8}''$	.179	$4\frac{1}{8}''$	.6565
$1\frac{1}{4}''$	.199	$4\frac{1}{4}''$	.6764
$1\frac{3}{8}''$	.2188	$4\frac{3}{8}''$	.6963
$1\frac{1}{2}''$	.2387	$4\frac{1}{2}''$	.7162
$1\frac{5}{8}''$	.2586	$4\frac{5}{8}''$	.7361
$1\frac{3}{4}''$	.2785	$4\frac{3}{4}''$	.756
$1\frac{7}{8}''$	.2984	$4\frac{7}{8}''$	.776
$2''$	.3183	$5''$	.7957
$2\frac{1}{8}''$	.3382	$5\frac{1}{8}''$	.8157
$2\frac{1}{4}''$	.3581	$5\frac{1}{4}''$	.8356
$2\frac{3}{8}''$	.378	$5\frac{3}{8}''$	.8555
$2\frac{1}{2}''$	.3979	$5\frac{1}{2}''$	.8754
$2\frac{5}{8}''$	.4178	$5\frac{5}{8}''$	.8953
$2\frac{3}{4}''$	.4377	$5\frac{3}{4}''$	.9152
$2\frac{7}{8}''$	.4576	$5\frac{7}{8}''$	.9351
$3''$	.4775	$6''$	.955

RULE. — Multiply the decimal number opposite the required pitch by the number of teeth, and the product will be the radius of the wheel.

TABLE OF DIAMETERS, CIRCUMFERENCES, AND AREAS OF CIRCLES,

And the contents in gallons (of 231 cubic inches) at 1 foot in depth.

Diameter.	Circumference.	Area.	Gallons.
	Inches.	Inches.	
1″	3.1416	.7854	.04084
⅛″	3.5343	.9940	.05169
¼″	3.9270	1.2271	.06380
⅜″	4.3197	1.4848	.07717
½″	4.7124	1.7671	.09188
⅝″	5.1051	2.0739	.10782
¾″	5.4978	2.4052	.12506
⅞″	5.8905	2.7611	.14357
2″	6.2832	3.1416	.16333
⅛″	6.6759	3.5465	.18439
¼″	7.0686	3.9760	.20675
⅜″	7.4613	4.4302	.23036
½″	7.8540	4.9087	.25522
⅝″	8.2467	5.4119	.28142
¾″	8.6394	5.9395	.30883
⅞″	9.0321	6.4918	.33753
3″	9.4248	7.0686	.36754
⅛″	9.8175	7.6699	.39879
¼″	10.210	8.2957	.43134
⅜″	10.602	8.9462	.46519
½″	10.995	9.6211	.50029
⅝″	11.388	10.320	.53664
¾″	11.781	11.044	.57429
⅞″	12.173	11.793	.61324
4″	12.566	12.566	.65343
⅛″	12.959	13.364	.69493
¼″	13.351	14.186	.73767
⅜″	13.744	15.033	.78172
½″	14.137	15.904	.82701
⅝″	14.529	16.800	.87360
¾″	14.922	17.720	.92144
⅞″	15.315	18.665	.97058
5″	15.708	19.635	1.02102
⅛″	16.100	20.629	1.07271

CIRCLES, — *Continued.*

Diameter.	Circumference.	Area.	Gallons.
	Inches.	Inches.	
¼″	16.493	21.647	1.12564
⅜″	16.886	22.690	1.17988
½″	17.278	23.758	1.23542
⅝″	17.671	24.850	1.29220
¾″	18.064	25.967	1.35128
⅞″	18.457	27.108	1.40962
6″	18.849	28.274	1.47025
⅛″	19.242	29.464	1.53213
¼″	19.635	30.679	1.59531
⅜″	20.027	31.919	1.65979
½″	20.420	33.183	1.72552
⅝″	20.813	34.471	1.79249
¾″	21.205	35.784	1.86077
⅞″	21.598	37.122	1.93034
7″	21.991	38.484	2.00117
⅛″	22.383	39.871	2.07329
¼″	22.776	41.282	2.14666
⅜″	23.169	42.718	2.22134
½″	23.562	44.178	2.29726
⅝″	23.954	45.663	2.37448
¾″	24.347	47.173	2.45299
⅞″	24.740	48.707	2.53276
8″	25.132	50.265	2.61378
⅛″	25.515	51.848	2.69609
¼″	25.918	53.456	2.77971
⅜″	26.310	55.088	2.86458
½″	26.703	56.745	2.95074
⅝″	27.096	58.426	3.03815
¾″	27.489	60.132	3.12686
⅞″	27.881	61.862	3.21682
9″	28.274	63.617	3.30808
⅛″	28.667	65.396	3.40059
¼″	29.059	67.200	3.49440
⅜″	29.452	69.029	3.58951
½″	29.845	70.882	3.68586
⅝″	30.237	72.759	3.78347
¾″	30.630	74.662	3.88242

CIRCLES, — *Continued.*

Diameter.	Circumference.	Area.	Gallons.
	Inches.	Inches.	
$\frac{7}{8}''$	31.023	76.588	3.98258
10″	31.416	78.540	4.08408
$\frac{1}{8}''$	31.808	80.515	4.18678
$\frac{1}{4}''$	32.201	82.516	4.29083
$\frac{3}{8}''$	32.594	84.540	4.39608
$\frac{1}{2}''$	32.986	86.590	4.50268
$\frac{5}{8}''$	33.379	88.664	4.61053
$\frac{3}{4}''$	33.772	90.762	4.71962
$\frac{7}{8}''$	34.164	92.885	4.82846
11″	34.557	95.033	4.94172
$\frac{1}{8}''$	35.950	97.205	5.05466
$\frac{1}{4}''$	35.343	99.402	5.16890
$\frac{3}{8}''$	35.735	101.623	5.28439
$\frac{1}{2}''$	36.128	103.869	5.40119
$\frac{5}{8}''$	36.521	106.839	5.51923
$\frac{3}{4}''$	36.913	108.434	5.63857
$\frac{7}{8}''$	37.306	110.753	5.75916
		Feet.	
1′	3′ $1\frac{5}{8}''$	.7854	5.8735
1′ 1″	3′ $4\frac{5}{8}''$	.9217	6.8928
1′ 2″	3′ 8″	1.0690	7.9944
1′ 3″	3′ 11″	1.2271	9.1766
1′ 4″	4′ $2\frac{1}{8}''$	1.3962	10.4413
1′ 5″	4′ $5\frac{3}{8}''$	1.5761	11.7866
1′ 6″	4′ $8\frac{1}{2}''$	1.7671	13.2150
1′ 7″	4′ $11\frac{5}{8}''$	1.9689	14.7241
1′ 8″	5′ $2\frac{3}{4}''$	2.1816	16.3148
1′ 9″	5′ $5\frac{7}{8}''$	2.4052	17.9870
1′ 10″	5′ 9″	2.6398	19.7414
1′ 11″	6′ $2\frac{1}{4}''$	2.8852	21.4830
2′	6′ $3\frac{3}{8}''$	3.1416	23.4940
2′ 1″	6′ $6\frac{1}{2}''$	3.4087	25.4916
2′ 2″	6′ $9\frac{5}{8}''$	3.6869	27.5720
2′ 3″	7′ $\frac{3}{4}''$	3.9760	29.7340
2′ 4″	7′ $3\frac{7}{8}''$	4.2760	32.6976
2′ 5″	7′ 7″	4.5869	34.3027
2′ 6″	7′ $10\frac{1}{4}''$	4.9087	36.7092

CIRCLES, — *Continued.*

Diameter.	Circumference.	Area.	Gallons.
		Feet.	
2′ 7″	8′ 1⅜″	5.2413	36.1964
2′ 8″	8′ 4½″	5.5850	41.7668
2′ 9″	8′ 7⅝″	5.9395	44.4179
2′ 10″	8′ 10¾″	6.3049	47.1505
2′ 11″	9′ 1⅞″	6.6813	49.9654
3′	9′ 5″	7.0686	52.8618
3′ 1″	9′ 8¼″	7.4666	55.8382
3′ 2″	9′ 11⅜″	7.8757	58.8976
3′ 3″	10′ 2½″	8.2957	62.0386
3′ 4″	10′ 5⅝″	8.7265	65.2602
3′ 5″	10′ 8¾″	9.1683	68.5193
3′ 6″	10′ 11⅞″	9.6211	73.1504
3′ 7″	11′ 3″	10.0846	75.4166
3′ 8″	11′ 6⅛″	10.5591	78.9652
3′ 9″	11′ 9⅜″	11.0446	82.5959
3′ 10″	12′ 5½″	11.5409	86.3074
3′ 11″	12′	12.0481	90.1004
4′	12′ 6¾″	12.5664	93.9754
4′ 1″	12′ 9⅞″	13.0952	97.9310
4′ 2″	13′ 1″	13.6353	101.9701
4′ 3″	13′ 4⅛″	14.1862	103.0300
4′ 4″	13′ 7¼″	14.7479	110.2907
4′ 5″	13′ 10½″	15.3206	114.5735
4′ 6″	14′ 1⅝″	15.9043	118.9386
4′ 7″	14′ 4⅝″	16.4986	123.3830
4′ 8″	14′ 7⅞″	17.1041	127.9112
4′ 9″	14′ 11″	17.7205	132.5209
4′ 10″	15′ 2⅛″	18.3476	137.2105
4′ 11″	15′ 5¼″	18.9858	142.0582
5′	15′ 8½″	19.6350	146.8384
5′ 1″	15′ 11⅝″	20.2947	151.7718
5′ 2″	16′ 2¾″	20.9656	156.7891
5′ 3″	16′ 5¾″	21.6475	161.8886
5′ 4″	16′ 9″	22.3400	167.0674
5′ 5″	17′ ⅛″	23.0437	172.3300
5′ 6″	17′ 3¼″	23.7583	177.6740
5′ 7″	17′ 6⅜″	24.4835	183.0973

CIRCLES, — *Continued.*

Diameter.	Circumference.	Area.	Gallons.
		Feet.	
5′ 8″	17′ $9\frac{5}{8}$″	25.2199	188.6045
5′ 9″	18′ $\frac{3}{4}$″	25.9672	194.1930
5′ 10″	18′ $3\frac{7}{8}$″	26.7251	199.8610
5′ 11″	18′ $7\frac{1}{8}$″	27.4943	205.6133
6′	18′ $10\frac{1}{8}$″	28.2744	211.4472
6′ 3″	19′ $7\frac{1}{2}$″	30.6796	229.4342
6′ 6″	20′ $4\frac{7}{8}$″	33.1831	248.1564
6′ 9″	21′ $2\frac{3}{8}$″	35.7847	267.6122
7′	21′ $11\frac{7}{8}$″	38.4846	287.8032
7′ 3″	22′ $9\frac{1}{4}$″	41.2825	308.7270
7′ 6″	23′ $6\frac{3}{4}$″	44.1787	330.3859
7′ 9″	24′ $4\frac{1}{8}$″	47.1730	352.7665
8′	25′ $1\frac{1}{2}$″	50.2656	375.9062
8′ 3″	25′ 11″	53.4562	399.7668
8′ 6″	26′ $8\frac{3}{8}$″	56.7451	424.3625
8′ 9″	27′ $5\frac{3}{4}$″	60.1321	449.2118
9′	28′ $3\frac{1}{4}$″	63.6174	475.7563
9′ 3″	29′ $\frac{5}{8}$″	67.2007	502.5536
9′ 6″	29′ $10\frac{1}{8}$″	70.8823	530.0861
9′ 9″	30′ $7\frac{1}{2}$″	74.6620	558.3522
10′	31′ 5″	78.5400	587.3534
10′ 3″	32′ $2\frac{3}{8}$″	82.5160	617.0876
10′ 6″	32′ $11\frac{3}{4}$″	86.5903	647.5568
10′ 9″	33′ $9\frac{1}{4}$″	90.7627	678.2797
11′	34′ $6\frac{5}{8}$″	95.0334	710.6977
11′ 3″	35′ $4\frac{1}{8}$″	99.4021	743.3686
11′ 6″	36′ $1\frac{1}{2}$″	103.8691	776.7746
11′ 9″	36′ $10\frac{7}{8}$″	108.4342	810.9143
12′	37′ $8\frac{3}{8}$″	113.0976	848.1890
12′ 3″	38′ $5\frac{3}{4}$″	117.8590	881.3966
12′ 6″	39′ $3\frac{1}{4}$″	122.7187	917.7395
12′ 9″	40′ $\frac{5}{8}$″	127.6765	954.8159
13′	40′ 10″	132.7326	992.6274
13′ 3″	41′ $7\frac{1}{2}$″	137.8867	1031.1719
13′ 6″	42′ $4\frac{7}{8}$″	143.1391	1070.4514
13′ 9″	43′ $2\frac{1}{4}$″	148.4896	1108.0645
14′	43′ $11\frac{3}{4}$″	153.9384	1151.2129

CIRCLES, — *Concluded.*

Diameter.	Circumference.	Area.	Gallons.
		Feet.	
14′ 3″	44′ 9⅛″	159.4852	1192.6940
14′ 6″	45′ 6⅝″	165.1303	1234.9104
14′ 9″	46′ 4″	170.8735	1277.8615
15′	47′ 1½″	176.7150	1321.5454
15′ 3″	47′ 10⅞″	182.6545	1365.9634
15′ 6″	48′ 8¼″	188.6923	1407.5165
15′ 9″	49′ 5¾″	194.8282	1457.0032
16′	50′ 3⅛″	201.0624	1503.6250
16′ 3″	51′ ½″	207.3946	1550.9797
16′ 6″	51′ 10″	213.8251	1599.0696
16′ 9″	52′ 7⅜″	220.3537	1647.8930
17′	53′ 4⅞″	226.9806	1697.4516
17′ 3″	54′ 2⅛″	233.7055	1747.7431
17′ 6″	54′ 11⅝″	240.5287	1798.7698
17′ 9″	55′ 9⅛″	247.4500	1850.5301
18′	56′ 6½″	254.4696	1903.0254
18′ 3″	57′ 4″	261.5872	1956.2537
18′ 6″	58′ 1⅜″	268.8031	2010.2171
18′ 9″	58′ 10¾″	276.1171	2064.9140

The American standard gallon contains 231 cubic inches, or $8\frac{1}{3}$ pounds of pure water. A cubic foot contains 62.3 pounds of water, or 7.48 gallons. Pressure per square inch is equal to the depth or head in feet multiplied by .433. Each 27.72 inches of depth gives a pressure of one pound to the square inch. Multiplying imperial gallons by 1.2 will convert them into American standard gallons of 231 cubic inches.

WEIGHTS OF MATERIALS.

Per Cubic Foot.	lbs.	Per Cubic Foot.	lbs.
Water	62.3	Masonry	116–144
Fire-brick	137	Sandstone	144
Brick-work	112	Slate	178
Coal, anthracite (solid)	100	Common gravel . . .	109
" " (broken)	57	Mud	102
" bituminous . . .	77–90	Mortar	98
Coke	62–104	Concrete	125
Granite	164–172	Common soil	137
Plaster of Paris . . .	73.5	Glass	165
Limestone	169–175		

1 bushel of bituminous coal weighs 80 pounds: 28 bushels = 1 ton of 2,240 pounds.

DECIMAL EQUIVALENTS.

TABLE OF FRACTIONS OF A LINEAL INCH CONVERTED INTO DECIMALS.

8ths.	32ds.	64ths.	
$\frac{1}{8} = .125$	$\frac{1}{32} = .03125$	$\frac{1}{64} = .015625$	$\frac{33}{64} = .515625$
$\frac{1}{4} = .25$	$\frac{3}{32} = .09375$	$\frac{3}{64} = .046875$	$\frac{35}{64} = .546875$
$\frac{3}{8} = .375$	$\frac{5}{32} = .15625$	$\frac{5}{64} = .078125$	$\frac{37}{64} = .578125$
$\frac{1}{2} = .50$	$\frac{7}{32} = .21875$	$\frac{7}{64} = .109375$	$\frac{39}{64} = .609375$
$\frac{5}{8} = .625$	$\frac{9}{32} = .28125$	$\frac{9}{64} = .140625$	$\frac{41}{64} = .640625$
$\frac{3}{4} = .75$	$\frac{11}{32} = .34375$	$\frac{11}{64} = .17185$	$\frac{43}{64} = .671875$
$\frac{7}{8} = .875$	$\frac{13}{32} = .40625$	$\frac{13}{64} = .203125$	$\frac{45}{64} = .703125$
16ths.	$\frac{15}{32} = .46875$	$\frac{15}{64} = .234375$	$\frac{47}{64} = .734375$
$\frac{1}{16} = .0625$	$\frac{17}{32} = .53125$	$\frac{17}{64} = .265625$	$\frac{49}{64} = .765625$
$\frac{3}{16} = .1875$	$\frac{19}{32} = .59375$	$\frac{19}{64} = .296875$	$\frac{51}{64} = .796875$
$\frac{5}{16} = .3125$	$\frac{21}{32} = .65625$	$\frac{21}{64} = .328125$	$\frac{53}{64} = .828125$
$\frac{7}{16} = .4375$	$\frac{23}{32} = .71875$	$\frac{23}{64} = .359375$	$\frac{55}{64} = .859375$
$\frac{9}{16} = .5625$	$\frac{25}{32} = .78125$	$\frac{25}{64} = .390625$	$\frac{57}{64} = .890625$
$\frac{11}{16} = .6875$	$\frac{27}{32} = .84375$	$\frac{27}{64} = .421875$	$\frac{59}{64} = .921875$
$\frac{13}{16} = .8125$	$\frac{29}{32} = .90625$	$\frac{29}{64} = .453125$	$\frac{61}{64} = .953125$
$\frac{15}{16} = .9375$	$\frac{31}{32} = .96875$	$\frac{31}{64} = .484375$	$\frac{63}{64} = .984375$

CONVERSION OF FRACTIONS OF AN INCH INTO DECIMALS OF A LINEAL FOOT.

$\frac{1}{64}'' = 0.001375'$	$\frac{3}{8}'' = 0.03125'$
$\frac{1}{32}'' = 0.00265'$	$\frac{1}{2}'' = 0.04166'$
$\frac{1}{16}'' = 0.005208'$	$\frac{5}{8}'' = 0.05208'$
$\frac{1}{8}'' = 0.01041'$	$\frac{3}{4}'' = 0.0625'$
$\frac{1}{4}'' = 0.02083'$	$\frac{7}{8}'' = 0.07291'$

A TABLE OF THE RECIPROCALS OF NUMBERS;

Or, the decimal fractions corresponding to vulgar fractions of which the numerator is unity, or 1.

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{2}$	.5	$\frac{1}{35}$	.028571429	$\frac{1}{68}$	.014705882
$\frac{1}{3}$	.333333333	$\frac{1}{36}$	.027777778	$\frac{1}{69}$	.014492754
$\frac{1}{4}$	.25	$\frac{1}{37}$	.027027027	$\frac{1}{70}$	.014285714
$\frac{1}{5}$	.2	$\frac{1}{38}$	.026315789	$\frac{1}{71}$	.014084517
$\frac{1}{6}$	.166666667	$\frac{1}{39}$	.025641026	$\frac{1}{72}$	.013888889
$\frac{1}{7}$	.142857143	$\frac{1}{40}$	.025	$\frac{1}{73}$	.01369863
$\frac{1}{8}$	.125	$\frac{1}{41}$	.024390244	$\frac{1}{74}$	.013513514
$\frac{1}{9}$	.111111111	$\frac{1}{42}$	.023809524	$\frac{1}{75}$	.013333333
$\frac{1}{10}$	.1	$\frac{1}{43}$	.023255814	$\frac{1}{76}$	.013157895
$\frac{1}{11}$	.090909091	$\frac{1}{44}$	.022727273	$\frac{1}{77}$	.012987013
$\frac{1}{12}$	.083333333	$\frac{1}{45}$	.022222222	$\frac{1}{78}$	.012820513
$\frac{1}{13}$	.076923077	$\frac{1}{46}$	.02173913	$\frac{1}{79}$	.012658228
$\frac{1}{14}$	.071428571	$\frac{1}{47}$	.0212766	$\frac{1}{80}$	.0125
$\frac{1}{15}$	.066666667	$\frac{1}{48}$	.020833333	$\frac{1}{81}$	.012345679
$\frac{1}{16}$	.0625	$\frac{1}{49}$	.020408163	$\frac{1}{82}$	.012195122
$\frac{1}{17}$	.058823529	$\frac{1}{50}$	.02	$\frac{1}{83}$	.012048193
$\frac{1}{18}$	.055555556	$\frac{1}{51}$	.019607843	$\frac{1}{84}$	.011904762
$\frac{1}{19}$	.052631579	$\frac{1}{52}$	.019230769	$\frac{1}{85}$	.011764706
$\frac{1}{20}$	.05	$\frac{1}{53}$	.018867925	$\frac{1}{86}$	.011627907
$\frac{1}{21}$	.047619048	$\frac{1}{54}$	.018518519	$\frac{1}{87}$	.011494253
$\frac{1}{22}$	.045454545	$\frac{1}{55}$	.018181818	$\frac{1}{88}$	.011363636
$\frac{1}{23}$	.043478261	$\frac{1}{56}$	.017857143	$\frac{1}{89}$	.011235955
$\frac{1}{24}$	.041666667	$\frac{1}{57}$	.01754386	$\frac{1}{90}$	.011111111
$\frac{1}{25}$	.04	$\frac{1}{58}$	.017241379	$\frac{1}{91}$	.010989011
$\frac{1}{26}$	.038461538	$\frac{1}{59}$	.016949153	$\frac{1}{92}$	.010869565
$\frac{1}{27}$	.037037037	$\frac{1}{60}$	.016666667	$\frac{1}{93}$	.010752688
$\frac{1}{28}$	.035714286	$\frac{1}{61}$	.016393443	$\frac{1}{94}$	.010638298
$\frac{1}{29}$	.034482759	$\frac{1}{62}$	.016129032	$\frac{1}{95}$	.010526316
$\frac{1}{30}$	.033333333	$\frac{1}{63}$	.015873016	$\frac{1}{96}$	.010416667
$\frac{1}{31}$	.032258065	$\frac{1}{64}$	.015625	$\frac{1}{97}$	.010309278
$\frac{1}{32}$	.03125	$\frac{1}{65}$	.015384615	$\frac{1}{98}$	.010204082
$\frac{1}{33}$	.030303030	$\frac{1}{66}$	.015151515	$\frac{1}{99}$	.01010101
$\frac{1}{34}$	.029411765	$\frac{1}{67}$	.014925373	$\frac{1}{100}$	.01

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{101}$	.00990099	$\frac{1}{137}$	.00729927	$\frac{1}{173}$	.005780347
$\frac{1}{102}$	.009803922	$\frac{1}{138}$	.007246377	$\frac{1}{174}$	.005747126
$\frac{1}{103}$	.009708738	$\frac{1}{139}$	.007194245	$\frac{1}{175}$	.005714286
$\frac{1}{104}$	.009615385	$\frac{1}{140}$	.007142857	$\frac{1}{176}$	.005681818
$\frac{1}{105}$	.00952381	$\frac{1}{141}$	.007092199	$\frac{1}{177}$	.005649718
$\frac{1}{106}$	.009433962	$\frac{1}{142}$	.007042254	$\frac{1}{178}$	.005617978
$\frac{1}{107}$	.009345794	$\frac{1}{143}$	.006993007	$\frac{1}{179}$	.005586592
$\frac{1}{108}$	.009259259	$\frac{1}{144}$	.006944444	$\frac{1}{180}$	.005555556
$\frac{1}{109}$	.009174312	$\frac{1}{145}$	.006896552	$\frac{1}{181}$	.005524862
$\frac{1}{110}$	.009090909	$\frac{1}{146}$	.006849315	$\frac{1}{182}$	.005494505
$\frac{1}{111}$	.009009009	$\frac{1}{147}$	.006802721	$\frac{1}{183}$	.005464481
$\frac{1}{112}$	.008928571	$\frac{1}{148}$	.006756757	$\frac{1}{184}$	.005434783
$\frac{1}{113}$	.008849558	$\frac{1}{149}$	.006711409	$\frac{1}{185}$	.005405405
$\frac{1}{114}$	.00877193	$\frac{1}{150}$	.006666667	$\frac{1}{186}$	.005376344
$\frac{1}{115}$	.008695652	$\frac{1}{151}$	.006622517	$\frac{1}{187}$	.005347594
$\frac{1}{116}$	.00802069	$\frac{1}{152}$	.006578947	$\frac{1}{188}$	.005319149
$\frac{1}{117}$	.008547009	$\frac{1}{153}$	.006535948	$\frac{1}{189}$	.005291005
$\frac{1}{118}$	.008474576	$\frac{1}{154}$	.006493500	$\frac{1}{190}$	.005263158
$\frac{1}{119}$	.008403361	$\frac{1}{155}$	.006451613	$\frac{1}{191}$	.005235602
$\frac{1}{120}$	.008333333	$\frac{1}{156}$	.006410256	$\frac{1}{192}$	.005208333
$\frac{1}{121}$	.008264463	$\frac{1}{157}$	.006369427	$\frac{1}{193}$	.005181347
$\frac{1}{122}$	.008196721	$\frac{1}{158}$	.006329114	$\frac{1}{194}$	.005154639
$\frac{1}{123}$	.008130081	$\frac{1}{159}$	.006289308	$\frac{1}{195}$	.005128205
$\frac{1}{124}$	.008064516	$\frac{1}{160}$	.00625	$\frac{1}{196}$	.005102041
$\frac{1}{125}$	.008	$\frac{1}{161}$	.00621118	$\frac{1}{197}$	.005076142
$\frac{1}{126}$	.007936508	$\frac{1}{162}$	.00617284	$\frac{1}{198}$	.005050505
$\frac{1}{127}$	.007874016	$\frac{1}{163}$	.006134969	$\frac{1}{199}$	.005025126
$\frac{1}{128}$	.0078125	$\frac{1}{164}$	.006097561	$\frac{1}{200}$	.005
$\frac{1}{129}$	.007751938	$\frac{1}{165}$	.006060606	$\frac{1}{201}$	.004975124
$\frac{1}{130}$	.007692308	$\frac{1}{166}$	.006024096	$\frac{1}{202}$	.004950495
$\frac{1}{131}$	.007633588	$\frac{1}{167}$	.005988024	$\frac{1}{203}$	.004926108
$\frac{1}{132}$	.007575758	$\frac{1}{168}$	.005952381	$\frac{1}{204}$	.004901961
$\frac{1}{133}$	.007518797	$\frac{1}{169}$	.00591716	$\frac{1}{205}$	.004878049
$\frac{1}{134}$	.007462687	$\frac{1}{170}$	.005882353	$\frac{1}{206}$	.004854069
$\frac{1}{135}$	.007407407	$\frac{1}{171}$	.005847953	$\frac{1}{207}$	.004830918
$\frac{1}{136}$	.007352941	$\frac{1}{172}$	.005813953	$\frac{1}{208}$	.004807692

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{209}$	.004784689	$\frac{1}{245}$	.004081633	$\frac{1}{281}$	.003558719
$\frac{1}{210}$	.004761905	$\frac{1}{246}$	.004065041	$\frac{1}{282}$	.003546099
$\frac{1}{211}$	.004739336	$\frac{1}{247}$	.004048583	$\frac{1}{283}$	.003533569
$\frac{1}{212}$	.004716981	$\frac{1}{248}$	.004032258	$\frac{1}{284}$	.003522127
$\frac{1}{213}$	.004694836	$\frac{1}{249}$	.004016064	$\frac{1}{285}$	.003508722
$\frac{1}{214}$	.004672897	$\frac{1}{250}$	.004	$\frac{1}{286}$	.003496503
$\frac{1}{215}$	.004651163	$\frac{1}{251}$	.003984064	$\frac{1}{287}$	.003484321
$\frac{1}{216}$	.00462963	$\frac{1}{252}$	.003968254	$\frac{1}{288}$	.003472222
$\frac{1}{217}$	.004608295	$\frac{1}{253}$	.003952569	$\frac{1}{289}$	.003460208
$\frac{1}{218}$	.004587156	$\frac{1}{254}$	.003937008	$\frac{1}{290}$	.003448276
$\frac{1}{219}$	.00456621	$\frac{1}{255}$	.003921569	$\frac{1}{291}$	.003436426
$\frac{1}{220}$	.004545455	$\frac{1}{256}$	.00390625	$\frac{1}{292}$	.003424658
$\frac{1}{221}$	.004524887	$\frac{1}{257}$	.003891051	$\frac{1}{293}$	.003412969
$\frac{1}{222}$	.004504505	$\frac{1}{258}$	.003875969	$\frac{1}{294}$	.003401361
$\frac{1}{223}$	.004484305	$\frac{1}{259}$	.003861004	$\frac{1}{295}$	.003389831
$\frac{1}{224}$	.004464286	$\frac{1}{260}$	.003846154	$\frac{1}{296}$	.003378378
$\frac{1}{225}$	.004444444	$\frac{1}{261}$	.003831418	$\frac{1}{297}$	.003367003
$\frac{1}{226}$	.004424779	$\frac{1}{262}$	.003816794	$\frac{1}{298}$	.003355705
$\frac{1}{227}$	.004405286	$\frac{1}{263}$	.003802281	$\frac{1}{299}$	.003344482
$\frac{1}{228}$	.004385965	$\frac{1}{264}$	.003787879	$\frac{1}{300}$	.003333333
$\frac{1}{229}$	.004366812	$\frac{1}{265}$	.003773585	$\frac{1}{301}$	.003322259
$\frac{1}{230}$	.004347826	$\frac{1}{266}$	.003759398	$\frac{1}{302}$	.003311258
$\frac{1}{231}$	.004329004	$\frac{1}{267}$	.003745318	$\frac{1}{303}$	.00330133
$\frac{1}{232}$	.004310345	$\frac{1}{268}$	.003731343	$\frac{1}{304}$	.003289474
$\frac{1}{233}$	.004291845	$\frac{1}{269}$	.003717472	$\frac{1}{305}$	.003278689
$\frac{1}{234}$	.004273504	$\frac{1}{270}$	.003703704	$\frac{1}{306}$	.003267974
$\frac{1}{235}$	.004255319	$\frac{1}{271}$	.003690037	$\frac{1}{307}$	.003257329
$\frac{1}{236}$	.004237288	$\frac{1}{272}$	.003676471	$\frac{1}{308}$	.003246753
$\frac{1}{237}$	.004219409	$\frac{1}{273}$	.003663004	$\frac{1}{309}$	.003236246
$\frac{1}{238}$	.0042016S1	$\frac{1}{274}$	.003649635	$\frac{1}{310}$	.003225806
$\frac{1}{239}$	.0041841	$\frac{1}{275}$	.003636364	$\frac{1}{311}$	.003215434
$\frac{1}{240}$	.004166667	$\frac{1}{276}$	.003623188	$\frac{1}{312}$	.003205128
$\frac{1}{241}$	.004149378	$\frac{1}{277}$	.003610108	$\frac{1}{313}$	.003194888
$\frac{1}{242}$	.004132231	$\frac{1}{278}$	.003597122	$\frac{1}{314}$	.003184713
$\frac{1}{243}$	.004115226	$\frac{1}{279}$	.003584229	$\frac{1}{315}$	.003174603
$\frac{1}{244}$	.004098361	$\frac{1}{280}$	.003571429	$\frac{1}{316}$	.003164557

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{317}$	.003154574	$\frac{1}{353}$	.002832861	$\frac{1}{389}$	.002570694
$\frac{1}{318}$	.003144654	$\frac{1}{354}$	.002824859	$\frac{1}{390}$	.002564103
$\frac{1}{319}$	.003134796	$\frac{1}{355}$	.002816901	$\frac{1}{391}$	.002557545
$\frac{1}{320}$	.003125	$\frac{1}{356}$	.002808989	$\frac{1}{392}$	.00255102
$\frac{1}{321}$	.003115265	$\frac{1}{357}$	.00280112	$\frac{1}{393}$	.002544529
$\frac{1}{322}$	.00310559	$\frac{1}{358}$	.002793296	$\frac{1}{394}$	.002538071
$\frac{1}{323}$	.003095975	$\frac{1}{359}$	.002785515	$\frac{1}{395}$	.002531646
$\frac{1}{324}$	.00308642	$\frac{1}{360}$	.002777778	$\frac{1}{396}$	.002525253
$\frac{1}{325}$	.003076923	$\frac{1}{361}$	.002770083	$\frac{1}{397}$	.002518892
$\frac{1}{326}$	.003067485	$\frac{1}{362}$	.002762431	$\frac{1}{398}$	.002512563
$\frac{1}{327}$	.003058104	$\frac{1}{363}$	.002754821	$\frac{1}{399}$	.002506266
$\frac{1}{328}$	.00304878	$\frac{1}{364}$	.002747253	$\frac{1}{400}$	.0025
$\frac{1}{329}$	.003039514	$\frac{1}{365}$	.002739726	$\frac{1}{401}$	.002493766
$\frac{1}{330}$	.003030303	$\frac{1}{366}$	.00273224	$\frac{1}{402}$	.002487562
$\frac{1}{331}$	.003021148	$\frac{1}{367}$	.002724796	$\frac{1}{403}$	.00248139
$\frac{1}{332}$	.003012048	$\frac{1}{368}$	.002717391	$\frac{1}{404}$	.002475248
$\frac{1}{333}$	.003003003	$\frac{1}{369}$	.002710027	$\frac{1}{405}$	.002469136
$\frac{1}{334}$	.002994012	$\frac{1}{370}$	.002702703	$\frac{1}{406}$	.002463054
$\frac{1}{335}$	.002985075	$\frac{1}{371}$	.002695418	$\frac{1}{407}$	.002457002
$\frac{1}{336}$	.00297619	$\frac{1}{372}$	.002688172	$\frac{1}{408}$	.00245098
$\frac{1}{337}$	.002967359	$\frac{1}{373}$	.002680965	$\frac{1}{409}$	.002444988
$\frac{1}{338}$	.00295858	$\frac{1}{374}$	.002673797	$\frac{1}{410}$	.002439024
$\frac{1}{339}$	.002949853	$\frac{1}{375}$	.002666667	$\frac{1}{411}$	.00243309
$\frac{1}{340}$	.002941176	$\frac{1}{376}$	.002659574	$\frac{1}{412}$	.002427184
$\frac{1}{341}$	.002932551	$\frac{1}{377}$	.00265252	$\frac{1}{413}$	.002421308
$\frac{1}{342}$	.002923977	$\frac{1}{378}$	.002645503	$\frac{1}{414}$	.002415459
$\frac{1}{343}$	.002915452	$\frac{1}{379}$	.002638521	$\frac{1}{415}$	.002409639
$\frac{1}{344}$	.002906977	$\frac{1}{380}$	.002631579	$\frac{1}{416}$	.002403846
$\frac{1}{345}$	.002898551	$\frac{1}{381}$	.002624672	$\frac{1}{417}$	.002398082
$\frac{1}{346}$	.002890173	$\frac{1}{382}$	.002617801	$\frac{1}{418}$	.002392344
$\frac{1}{347}$	.002881844	$\frac{1}{383}$	.002610966	$\frac{1}{419}$	.002386635
$\frac{1}{348}$	.002873563	$\frac{1}{384}$	.002604167	$\frac{1}{420}$	.002380952
$\frac{1}{349}$	.00286533	$\frac{1}{385}$	.002597403	$\frac{1}{421}$	.002375297
$\frac{1}{350}$	.002857143	$\frac{1}{386}$	.002590674	$\frac{1}{422}$	.002369668
$\frac{1}{351}$	.002849003	$\frac{1}{387}$	.002583979	$\frac{1}{423}$	.002364066
$\frac{1}{352}$	.002840909	$\frac{1}{388}$	.00257732	$\frac{1}{424}$	.002358491

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{425}$	.002352941	$\frac{1}{461}$	.002169197	$\frac{1}{497}$	.002012072
$\frac{1}{426}$	.002347418	$\frac{1}{462}$	.002164502	$\frac{1}{498}$	.002008032
$\frac{1}{427}$	.00234192	$\frac{1}{463}$	.002159827	$\frac{1}{499}$	.002004008
$\frac{1}{428}$	.002336449	$\frac{1}{464}$	.002155172	$\frac{1}{500}$	.002
$\frac{1}{429}$	.002331002	$\frac{1}{465}$	.002150538	$\frac{1}{501}$	.001996008
$\frac{1}{430}$	.002325581	$\frac{1}{466}$	.002145923	$\frac{1}{502}$	.001992032
$\frac{1}{431}$	.002320186	$\frac{1}{467}$	.002141328	$\frac{1}{503}$	.001988072
$\frac{1}{432}$	.002314815	$\frac{1}{468}$	.002136752	$\frac{1}{504}$	.001984127
$\frac{1}{433}$	.002309469	$\frac{1}{469}$	.002132196	$\frac{1}{505}$	.001980198
$\frac{1}{434}$	.002304147	$\frac{1}{470}$	.00212766	$\frac{1}{506}$	.001976285
$\frac{1}{435}$	.002298851	$\frac{1}{471}$	.002123142	$\frac{1}{507}$	.001972387
$\frac{1}{436}$	.002293578	$\frac{1}{472}$	.002118644	$\frac{1}{508}$	.001968504
$\frac{1}{437}$	.00228833	$\frac{1}{473}$	.002114165	$\frac{1}{509}$	.001964637
$\frac{1}{438}$	.002283105	$\frac{1}{474}$	.002109705	$\frac{1}{510}$	.001960784
$\frac{1}{439}$	.002277904	$\frac{1}{475}$	.002105263	$\frac{1}{511}$	.001956947
$\frac{1}{440}$	.002272727	$\frac{1}{476}$	.00210084	$\frac{1}{512}$	.001953125
$\frac{1}{441}$	.002267574	$\frac{1}{477}$	.002096486	$\frac{1}{513}$	.001949318
$\frac{1}{442}$	.002262443	$\frac{1}{478}$	.00209205	$\frac{1}{514}$	.001945525
$\frac{1}{443}$	.002257336	$\frac{1}{479}$	.002087683	$\frac{1}{515}$	.001941748
$\frac{1}{444}$	.002252252	$\frac{1}{480}$	.002083333	$\frac{1}{516}$	.001937984
$\frac{1}{445}$	.002247151	$\frac{1}{481}$	.002079002	$\frac{1}{517}$	.001934236
$\frac{1}{446}$	.002242152	$\frac{1}{482}$	.002074689	$\frac{1}{518}$	.001930502
$\frac{1}{447}$	.002237136	$\frac{1}{483}$	.002070393	$\frac{1}{519}$	.001926782
$\frac{1}{448}$	.002232143	$\frac{1}{484}$	.002066116	$\frac{1}{520}$	.001923077
$\frac{1}{449}$	.002227171	$\frac{1}{485}$	.002061856	$\frac{1}{521}$	.001919386
$\frac{1}{450}$	.002222222	$\frac{1}{486}$	.002057613	$\frac{1}{522}$	.001915709
$\frac{1}{451}$	.002217295	$\frac{1}{487}$	.002053388	$\frac{1}{523}$	.001912046
$\frac{1}{452}$	.002212389	$\frac{1}{488}$	.00204918	$\frac{1}{524}$	.001908397
$\frac{1}{453}$	.002207506	$\frac{1}{489}$	.00204499	$\frac{1}{525}$	.001904762
$\frac{1}{454}$	.002202643	$\frac{1}{490}$	.002040816	$\frac{1}{526}$	.001901141
$\frac{1}{455}$	.002197802	$\frac{1}{491}$	.00203666	$\frac{1}{527}$	.001897533
$\frac{1}{456}$	.002192982	$\frac{1}{492}$	.00203252	$\frac{1}{528}$	.001893939
$\frac{1}{457}$	.002188184	$\frac{1}{493}$	.002028398	$\frac{1}{529}$	.001890359
$\frac{1}{458}$	.002183406	$\frac{1}{494}$	.002024291	$\frac{1}{530}$	.001886792
$\frac{1}{459}$	.002178649	$\frac{1}{495}$	.002020202	$\frac{1}{531}$	.001883239
$\frac{1}{460}$	.002173913	$\frac{1}{496}$	.002016129	$\frac{1}{532}$	.001879699

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{533}$	.001876173	$\frac{1}{569}$	.001757469	$\frac{1}{605}$	.001652893
$\frac{1}{534}$	.001872659	$\frac{1}{570}$	.001754386	$\frac{1}{606}$	.001650165
$\frac{1}{535}$	.001869159	$\frac{1}{571}$	.001751313	$\frac{1}{607}$	.001647446
$\frac{1}{536}$	.001865672	$\frac{1}{572}$	.001748252	$\frac{1}{608}$	.001644737
$\frac{1}{537}$	.001862197	$\frac{1}{573}$	.001745201	$\frac{1}{609}$	.001642036
$\frac{1}{538}$	.001858736	$\frac{1}{574}$	.00174216	$\frac{1}{610}$	.001639344
$\frac{1}{539}$	.001855288	$\frac{1}{575}$	.00173913	$\frac{1}{611}$	.001636661
$\frac{1}{540}$	.001851852	$\frac{1}{576}$	.001736111	$\frac{1}{612}$	.001633987
$\frac{1}{541}$	.001848429	$\frac{1}{577}$	.001733102	$\frac{1}{613}$	.001631321
$\frac{1}{542}$	.001845018	$\frac{1}{578}$	.001730104	$\frac{1}{614}$	.001628664
$\frac{1}{543}$	.001841621	$\frac{1}{579}$	.001727116	$\frac{1}{615}$	.001626016
$\frac{1}{544}$	.001838235	$\frac{1}{580}$	.001724138	$\frac{1}{616}$	.001623377
$\frac{1}{545}$	.001834262	$\frac{1}{581}$	.00172117	$\frac{1}{617}$	.001620746
$\frac{1}{546}$	.001831502	$\frac{1}{582}$	.001718213	$\frac{1}{618}$	.001618123
$\frac{1}{547}$	.001828154	$\frac{1}{583}$	.001715266	$\frac{1}{619}$	.001615509
$\frac{1}{548}$	.001824818	$\frac{1}{584}$	.001712329	$\frac{1}{620}$	.001612903
$\frac{1}{549}$	.001821494	$\frac{1}{585}$	.001709402	$\frac{1}{621}$	.001610306
$\frac{1}{550}$	.001818182	$\frac{1}{586}$	.001706485	$\frac{1}{622}$	.001607717
$\frac{1}{551}$	.001814882	$\frac{1}{587}$	.001703578	$\frac{1}{623}$	.001605136
$\frac{1}{552}$	.001811594	$\frac{1}{588}$	.00170068	$\frac{1}{624}$	.001602564
$\frac{1}{553}$	.001808318	$\frac{1}{589}$	.001697793	$\frac{1}{625}$	.0016
$\frac{1}{554}$	.001805054	$\frac{1}{590}$	.001694915	$\frac{1}{626}$	.001597444
$\frac{1}{555}$	.001801802	$\frac{1}{591}$	.001692047	$\frac{1}{627}$	.001594896
$\frac{1}{556}$	.001798561	$\frac{1}{592}$	.001689189	$\frac{1}{628}$	.001592357
$\frac{1}{557}$	.001795332	$\frac{1}{593}$	.001686341	$\frac{1}{629}$	.001589825
$\frac{1}{558}$	.001792115	$\frac{1}{594}$	.001683502	$\frac{1}{630}$	.001587302
$\frac{1}{559}$	.001788909	$\frac{1}{595}$	.001680672	$\frac{1}{631}$	.001584786
$\frac{1}{560}$	.001785714	$\frac{1}{596}$	.001677852	$\frac{1}{632}$	.001582278
$\frac{1}{561}$	.001782531	$\frac{1}{597}$	.001675042	$\frac{1}{633}$	.001579779
$\frac{1}{562}$	.001779359	$\frac{1}{598}$	.001672241	$\frac{1}{634}$	.001577287
$\frac{1}{563}$	.001776199	$\frac{1}{599}$	.001669449	$\frac{1}{635}$	.001574803
$\frac{1}{564}$	.00177305	$\frac{1}{600}$	.001666667	$\frac{1}{636}$	.001572327
$\frac{1}{565}$	.001769912	$\frac{1}{601}$	.001663894	$\frac{1}{637}$	.001569859
$\frac{1}{566}$	.001766784	$\frac{1}{602}$	.00166113	$\frac{1}{638}$	.001567398
$\frac{1}{567}$	.001763668	$\frac{1}{603}$	.001658375	$\frac{1}{639}$	.001564945
$\frac{1}{568}$	.001760563	$\frac{1}{604}$	.001655629	$\frac{1}{640}$	.0015625

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{641}$	.001560062	$\frac{1}{677}$	.001477105	$\frac{1}{713}$	.001402525
$\frac{1}{642}$	.001557632	$\frac{1}{678}$	.001474926	$\frac{1}{714}$	.00140056
$\frac{1}{643}$	.00155521	$\frac{1}{679}$	.001472754	$\frac{1}{715}$	.001398601
$\frac{1}{644}$	.001552795	$\frac{1}{680}$	.001470588	$\frac{1}{716}$	.001396648
$\frac{1}{645}$	.001550388	$\frac{1}{681}$	.001468429	$\frac{1}{717}$	.0013947
$\frac{1}{646}$	.001547988	$\frac{1}{682}$	.001466276	$\frac{1}{718}$	.001392758
$\frac{1}{647}$	.001545595	$\frac{1}{683}$	.001464129	$\frac{1}{719}$	.001390821
$\frac{1}{648}$	.00154321	$\frac{1}{684}$	.001461988	$\frac{1}{720}$	.001388889
$\frac{1}{649}$	.001540832	$\frac{1}{685}$	.001459854	$\frac{1}{721}$	.001386963
$\frac{1}{650}$	.001538462	$\frac{1}{686}$	.001457726	$\frac{1}{722}$	.001385042
$\frac{1}{651}$	.001536098	$\frac{1}{687}$	.001455604	$\frac{1}{723}$	.001383126
$\frac{1}{652}$	.001533742	$\frac{1}{688}$	.001453488	$\frac{1}{724}$	.001381215
$\frac{1}{653}$	.001531394	$\frac{1}{689}$	.001451379	$\frac{1}{725}$	.00137931
$\frac{1}{654}$	.001529052	$\frac{1}{690}$	.001449275	$\frac{1}{726}$	.00137741
$\frac{1}{655}$	.001526718	$\frac{1}{691}$	.001447178	$\frac{1}{727}$	.001375516
$\frac{1}{656}$	.00152439	$\frac{1}{692}$	.001445087	$\frac{1}{728}$	.001373626
$\frac{1}{657}$	.00152207	$\frac{1}{693}$	.001443001	$\frac{1}{729}$	.001371742
$\frac{1}{658}$	.001519751	$\frac{1}{694}$	.001440922	$\frac{1}{730}$	.001369863
$\frac{1}{659}$	.001517451	$\frac{1}{695}$	.001438849	$\frac{1}{731}$	.001367989
$\frac{1}{660}$	.001515152	$\frac{1}{696}$	.001436782	$\frac{1}{732}$	.00136612
$\frac{1}{661}$	.001512859	$\frac{1}{697}$	.00143472	$\frac{1}{733}$	.001364256
$\frac{1}{662}$	.001510574	$\frac{1}{698}$	.001432665	$\frac{1}{734}$	.001362398
$\frac{1}{663}$	.001508296	$\frac{1}{699}$	.001430615	$\frac{1}{735}$	.001360544
$\frac{1}{664}$	.001506024	$\frac{1}{700}$	.001428571	$\frac{1}{736}$	.001358696
$\frac{1}{665}$	.001503759	$\frac{1}{701}$	.001426534	$\frac{1}{737}$	.001356852
$\frac{1}{666}$	.001501502	$\frac{1}{702}$	.001424501	$\frac{1}{738}$	.001355014
$\frac{1}{667}$	.00149925	$\frac{1}{703}$	.001422475	$\frac{1}{739}$	.00135318
$\frac{1}{668}$	.001497006	$\frac{1}{704}$	.001420455	$\frac{1}{740}$	.001351351
$\frac{1}{669}$	.001494768	$\frac{1}{705}$	.00141844	$\frac{1}{741}$	.001349528
$\frac{1}{670}$	.001492537	$\frac{1}{706}$	.001416431	$\frac{1}{742}$	.001347709
$\frac{1}{671}$	.001490313	$\frac{1}{707}$	.001414427	$\frac{1}{743}$	.001345895
$\frac{1}{672}$	.001488095	$\frac{1}{708}$	.001412429	$\frac{1}{744}$	.001344086
$\frac{1}{673}$	.001485884	$\frac{1}{709}$	.001410437	$\frac{1}{745}$	.001342282
$\frac{1}{674}$	.00148368	$\frac{1}{710}$	.001408451	$\frac{1}{746}$	.001340483
$\frac{1}{675}$	.001481481	$\frac{1}{711}$	.00140647	$\frac{1}{747}$	.001338688
$\frac{1}{676}$	.00147929	$\frac{1}{712}$	.001404494	$\frac{1}{748}$	.001336898

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{749}$	.001335113	$\frac{1}{785}$	.001273885	$\frac{1}{821}$	.001218027
$\frac{1}{750}$	.001333333	$\frac{1}{786}$	.001272265	$\frac{1}{822}$	.001216545
$\frac{1}{751}$	.001331558	$\frac{1}{787}$	.001270648	$\frac{1}{823}$	.001215067
$\frac{1}{752}$	.001329787	$\frac{1}{788}$	.001269036	$\frac{1}{824}$	.001213592
$\frac{1}{753}$	.001328021	$\frac{1}{789}$	.001267427	$\frac{1}{825}$	.001212121
$\frac{1}{754}$	.00132626	$\frac{1}{790}$	.001265823	$\frac{1}{826}$	.001210654
$\frac{1}{755}$	.001324503	$\frac{1}{791}$	.001264223	$\frac{1}{827}$	.00120919
$\frac{1}{756}$	.001322751	$\frac{1}{792}$	.001262626	$\frac{1}{828}$	.001207729
$\frac{1}{757}$	.001321004	$\frac{1}{793}$	.001261034	$\frac{1}{829}$	.001206273
$\frac{1}{758}$	.001319261	$\frac{1}{794}$	.001259446	$\frac{1}{830}$	.001204819
$\frac{1}{759}$	.001317523	$\frac{1}{795}$	.001257862	$\frac{1}{831}$	.001203369
$\frac{1}{760}$	.001315789	$\frac{1}{796}$	.001256281	$\frac{1}{832}$	.001201923
$\frac{1}{761}$	.00131406	$\frac{1}{797}$	.001254705	$\frac{1}{833}$	.00120048
$\frac{1}{762}$	.001312336	$\frac{1}{798}$	.001253133	$\frac{1}{834}$	.001199041
$\frac{1}{763}$	.001310616	$\frac{1}{799}$	.001251364	$\frac{1}{835}$	.001197605
$\frac{1}{764}$	.001308901	$\frac{1}{800}$	.00125	$\frac{1}{836}$	.001196172
$\frac{1}{765}$	.00130719	$\frac{1}{801}$	.001248439	$\frac{1}{837}$	.001194743
$\frac{1}{766}$	.001305483	$\frac{1}{802}$	.001246883	$\frac{1}{838}$	.001193317
$\frac{1}{767}$	.001303781	$\frac{1}{803}$	.00124533	$\frac{1}{839}$	.001191895
$\frac{1}{768}$	.001302083	$\frac{1}{804}$	.001243781	$\frac{1}{840}$	.001190476
$\frac{1}{769}$	.00130039	$\frac{1}{805}$	.001242236	$\frac{1}{841}$	.001189061
$\frac{1}{770}$	.001298701	$\frac{1}{806}$	.001240695	$\frac{1}{842}$	.001187648
$\frac{1}{771}$	.001297017	$\frac{1}{807}$	.001239157	$\frac{1}{843}$	.00118624
$\frac{1}{772}$	.001295337	$\frac{1}{808}$	.001237624	$\frac{1}{844}$	.001184834
$\frac{1}{773}$	.001293661	$\frac{1}{809}$	.001236094	$\frac{1}{845}$	.001183432
$\frac{1}{774}$	.00129199	$\frac{1}{810}$	.001234568	$\frac{1}{846}$	.001182033
$\frac{1}{775}$	.001290323	$\frac{1}{811}$	.001233046	$\frac{1}{847}$	.001180638
$\frac{1}{776}$	.00128866	$\frac{1}{812}$	.001231527	$\frac{1}{848}$	.001179245
$\frac{1}{777}$	.001287001	$\frac{1}{813}$	.001230012	$\frac{1}{849}$	.001177856
$\frac{1}{778}$	.001285347	$\frac{1}{814}$	.001228501	$\frac{1}{850}$	.001176471
$\frac{1}{779}$	.001283697	$\frac{1}{815}$	.001226994	$\frac{1}{851}$	.001175088
$\frac{1}{780}$	.001282051	$\frac{1}{816}$	.001225499	$\frac{1}{852}$	.001173709
$\frac{1}{781}$	.00128041	$\frac{1}{817}$	.00122399	$\frac{1}{853}$	.001172333
$\frac{1}{782}$	.001278772	$\frac{1}{818}$	.001222494	$\frac{1}{854}$	.00117096
$\frac{1}{783}$	.001277139	$\frac{1}{819}$	.001221001	$\frac{1}{855}$	.001169591
$\frac{1}{784}$	.00127551	$\frac{1}{820}$	.001219512	$\frac{1}{856}$	.001168224

RECIPROCALS OF NUMBERS, — *Continued.*

Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.	Fraction or Number.	Decimal or Reciprocal.
$\frac{1}{857}$	.001166861	$\frac{1}{893}$	.001119821	$\frac{1}{929}$	.001076426
$\frac{1}{858}$	.001165501	$\frac{1}{894}$	.001118568	$\frac{1}{930}$	.001075269
$\frac{1}{859}$	.001164144	$\frac{1}{895}$	.001117818	$\frac{1}{931}$	.001074114
$\frac{1}{860}$	.001162791	$\frac{1}{896}$	.001116071	$\frac{1}{932}$	.001072961
$\frac{1}{861}$	.00116144	$\frac{1}{897}$	.001114827	$\frac{1}{933}$	.001071811
$\frac{1}{862}$	.001160093	$\frac{1}{898}$	.001113586	$\frac{1}{934}$	.001070664
$\frac{1}{863}$	.001158749	$\frac{1}{899}$	.001112347	$\frac{1}{935}$	.001069519
$\frac{1}{864}$	.001157407	$\frac{1}{900}$	.001111111	$\frac{1}{936}$	.001068376
$\frac{1}{865}$	.001156069	$\frac{1}{901}$	.001109878	$\frac{1}{937}$	.001067236
$\frac{1}{866}$	.001154734	$\frac{1}{902}$	.001108647	$\frac{1}{938}$	.001066098
$\frac{1}{867}$	.001153403	$\frac{1}{903}$	.00110742	$\frac{1}{939}$	.001064963
$\frac{1}{868}$	.001152074	$\frac{1}{904}$	.001106195	$\frac{1}{940}$	.00106383
$\frac{1}{869}$	.001150748	$\frac{1}{905}$	.001104972	$\frac{1}{941}$	.001062699
$\frac{1}{870}$	.001149425	$\frac{1}{906}$	.001103753	$\frac{1}{942}$	.001061571
$\frac{1}{871}$	.001148106	$\frac{1}{907}$	.001102536	$\frac{1}{943}$	.001060445
$\frac{1}{872}$	.001146789	$\frac{1}{908}$	.001101322	$\frac{1}{944}$	.001059322
$\frac{1}{873}$	.001145475	$\frac{1}{909}$	.00110011	$\frac{1}{945}$	.001058201
$\frac{1}{874}$	.001144165	$\frac{1}{910}$	.001098901	$\frac{1}{946}$	.001057082
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